



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵ : C12N 15/49, 15/86, A61K 39/21 C07K 13/00	A1	(11) International Publication Number: WO 92/22654 (43) International Publication Date: 23 December 1992 (23.12.92)
--	----	---

(21) International Application Number: PCT/US92/04980

(22) International Filing Date: 10 June 1992 (10.06.92)

(30) Priority data:
714,152 11 June 1991 (11.06.91) US

(71) Applicant: MICROGENESYS, INC. [US/US]; 1000 Research Parkway, Meriden, CT 06450 (US).

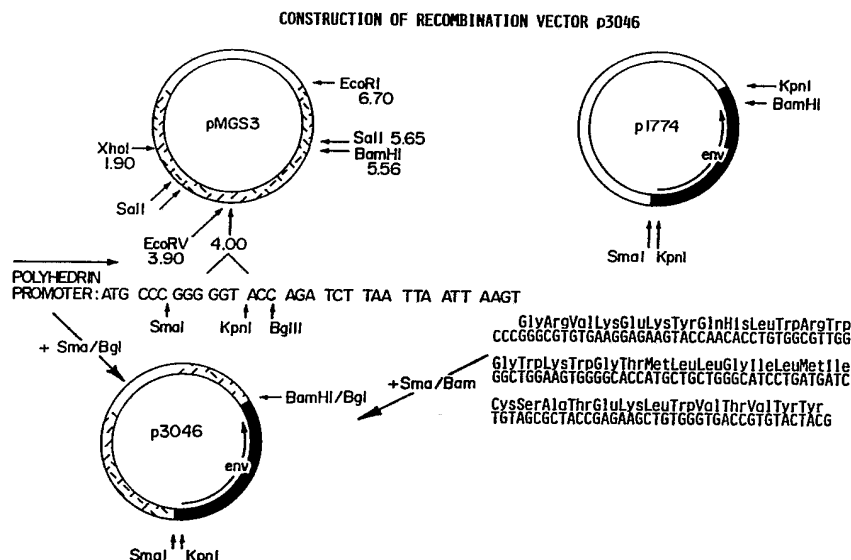
(72) Inventors: SMITH, Gale, E. ; 125 Michael Drive, Guilford, CT 06606 (US). VOLVOVITZ, Franklin ; 123 York St. #18E, New Haven, CT 06511 (US).

(74) Agents: SCHAFFER, Robert et al.; Darby & Darby, 805 Third Avenue, New York, NY 10022-7513 (US).

(81) Designated States: AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH (European patent), CI (OAPI patent), CM (OAPI patent), CS, DE (European patent), DK (European patent), ES (European patent), FI, FR (European patent), GA (OAPI patent), GB (European patent), GN (OAPI patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU (European patent), MC (European patent), MG, ML (OAPI patent), MN, MR (OAPI patent), MW, NL (European patent), NO, PL, RO, RU, SD, SE (European patent), SN (OAPI patent), TD (OAPI patent), TG (OAPI patent).

Published*With international search report.**Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.*

(54) Title: VACCINE AND TREATMENT METHOD OF HUMAN IMMUNODEFICIENCY VIRUS INFECTION



(57) Abstract

An Acquired Immunodeficiency Syndrome (AIDS) vaccine containing the Human Immunodeficiency Virus, Type-1 (HIV-1) envelope proteins is produced from cloned HIV-1 envelope genes in a baculovirus-insect cell vector system. The recombinant HIV-1 proteins are purified, assembled into particles and then adsorbed on an aluminum phosphate adjuvant. The resulting adsorbed recombinant HIV-1 virus envelope protein formulation (AIDS vaccine) is highly immunogenic in animals and elicits antibodies which bind to the HIV-1 virus envelope and neutralize the infectivity of the virus in *in vitro* tests. The above AIDS vaccine induces new humoral and cellular immune responses in HIV-infected patients and is useful as a form of vaccine therapy to delay or prevent the destruction of the immune system.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FI	Finland	MI	Mali
AU	Australia	FR	France	MN	Mongolia
BB	Barbados	GA	Gabon	MR	Mauritania
BE	Belgium	GB	United Kingdom	MW	Malawi
BF	Burkina Faso	GN	Guinea	NL	Netherlands
BG	Bulgaria	GR	Greece	NO	Norway
BJ	Benin	HU	Hungary	PL	Poland
BR	Brazil	IE	Ireland	RO	Romania
CA	Canada	IT	Italy	RU	Russian Federation
CF	Central African Republic	JP	Japan	SD	Sudan
CG	Congo	KP	Democratic People's Republic of Korea	SE	Sweden
CH	Switzerland	KR	Republic of Korea	SN	Senegal
CI	Côte d'Ivoire	LI	Liechtenstein	SU	Soviet Union
CM	Cameroon	LK	Sri Lanka	TD	Chad
CS	Czechoslovakia	LU	Luxembourg	TG	Togo
DE	Germany	MC	Monaco	US	United States of America
DK	Denmark	MG	Madagascar		
ES	Spain				

5

1

10 VACCINE AND TREATMENT METHOD OF HUMAN IMMUNODEFICIENCY VIRUS INFECTION

This application is a Continuation-in-part of U.S. Patent Application Serial No. 151,976 filed February 3, 1988
15 which is a Continuation-in-part of U.S. Patent application Serial No. 920,197 filed October 16, 1986 (now Serial No. 585,266). These applications and the references cited herein are incorporated by reference in their entirety.

20 BACKGROUND OF THE INVENTION

The Human Immunodeficiency Virus Type-1 (HIV-1) is a retrovirus which causes a systemic infection with a major pathology in the immune system and is the etiological agent responsible for Acquired Immune Deficiency Syndrome (AIDS).
25 Barre-Sinoussi, et al., Science, 220: 868-871 (1983); Popovic et al., Science, 224: 497-500 (1984). Clinical isolates of HIV-1 have also been referred to as Lymphadenopathy-Associated Virus (Feorino, et al., Science, 225: 69-72 (1984) and AIDS-related Virus (Levy et al.,
30 Science 225: 840-842 (1984)).

AIDS has become pandemic and the development of a vaccine has become a major priority for world public health. A high percentage of persons infected with HIV-1 show a progressive loss of immune function due to the depletion of
35 T4 lymphocytes. These T4 cells, as well as certain nerve cells, have a molecule on their surface called CD4. HIV-1 recognizes the CD4 molecule through a receptor located on the envelope of the virus particles, enters these cells, and eventually replicates and kills the cell. An effective AIDS

vaccine might be expected to elicit antibodies which would bind to the envelope of HIV-1 and prevent it from infecting T4 lymphocytes or other susceptible cells.

Vaccines are generally given to healthy individuals before they are exposed to a disease organism as an immune prophylactic. However, it is also reasonable to consider using an effective AIDS vaccine in post-exposure immunization as immunotherapy against the disease. Salk, J., Nature, 327: 473-476 (1987).

It is widely believed that the HIV-1 envelope ("env") is the most promising candidate in the development of an AIDS vaccine. Francis and Petricciani. New Eng. J. Med., 1586-1559 (1985); Vogt and Hirsh, Reviews of Infectious Disease, 8: 991-1000 (1986); Fauci, Proc. Natl. Acad. Sci. USA, 83: 9278-9283. The HIV-1 envelope protein is initially synthesized as a 160,000 molecular weight glycoprotein (gp160). The gp160 precursor is then cleaved into a 120,000 molecular weight external glycoprotein (gp120) and a 41,000 molecular weight transmembrane glycoprotein (gp41). These envelope proteins are the major target antigens for antibodies in AIDS patients. Barin, et al., Science, 228: 1094-1096 (1985). The native HIV-1 gp120 has been shown to be immunogenic and capable of inducing neutralizing antibodies in rodents, goats, rhesus monkeys and chimpanzees. Robey, et al., Proc. Natl. Acad. Sci. USA 83:7023-7027 (1986).

Due to the very low levels of native HIV-1 envelope protein in infected cells and the risks associated with preparing an AIDS vaccine from HIV-1 infected cells, recombinant DNA methods have been employed to produce HIV-1 envelope antigens for use as AIDS vaccines. Recombinant DNA technology appears to present the best option for the production of an AIDS subunit vaccine because of the ability to produce large quantities of safe and economical immunogens. The HIV-1 envelope protein has been expressed in genetically altered vaccinia virus recombinants. Chakrabarti, et al., Nature, 320: 535-537 (1986); Hu, et al., Nature, 320: 537-540 (1986); Kieny, et al.,

Biotechnology, 4:790-795 (1986). The envelope protein has also been expressed in bacterial cells (Putney, et al., Science, 234: 1392-1395 (1986)), in mammalian cells (Lasky, et al., Science, 23:209-12 (1986)), and in insect cells.

5 Synthetic peptides derived from amino acid sequences in an HIV-1 gp41 have also been considered as candidate AIDS vaccines. Kennedy, et al. (1986). However, a successful AIDS vaccine has not been produced using these materials and methods.

10 The use of a baculovirus-insect cell vector system to produce recombinant HIV-1 envelope proteins is one aspect of the invention disclosed in copending and coassigned U.S. patent application Serial No. 920,197 filed October 16, 1986 (now Serial No. 585,266). See also, Serial
15 No. 151,976.

The baculovirus system has been demonstrated to be of general utility in producing HIV-1 proteins and other proteins. As examples, the baculovirus Autographa californica nuclear polyhedrosis virus (AcNPV) has been used
20 as a vector for the expression of the full length gp160 and various portions of the HIV-1 envelope gene in infected Spodoptera frugiperda (fall armyworm) cells (Sf9 cells). Also disclosed in the prior copending patent applications is the truncated gp160 gene (recombinant number Ac3046), the
25 protein produced from recombinant Ac3046, and a purification technique for the Ac3046 gene product that includes lentil lectin affinity chromatography and gel filtration chromatography. The gp160 protein purified in this manner and aggregated to form particles was found to be highly
30 immunogenic in rodent and primate species.

The ideal AIDS vaccine, in addition to the requirements of being substantially biologically pure and non-pyrogenic, should provide life-long protection against infection with HIV-1 after a single or a few injections.
35 This is usually the case with live attenuated vaccines. When killed bacteria or viruses, or materials isolated from them, such as toxoids or proteins, are used to make a vaccine, there often results a poor antibody response and

only short term immunity. To overcome or minimize these deficiencies in a vaccine, an additional component, called an adjuvant, may be added. Adjuvants are materials which help stimulate the immune response. Adjuvants in common use
5 in human vaccines are gels of aluminum salts (aluminum phosphate or aluminum hydroxide), usually referred to as alum adjuvants. Bomford, et al., "Adjuvants," Animal Cell Biotech. Vol. 2: 235-250, Academic Press Inc. (London: 1985).

10 The present invention provides a vaccine and treatment methods for human immunodeficiency virus (HIV), comprising the administration of recombinant HIV envelope protein to an infected or susceptible individual. In a preferred embodiment, the envelope protein may be purified,
15 aggregated, and combined with an adjuvant (e.g., alum) for vaccine use.

BRIEF DESCRIPTION OF THE DRAWINGS

Details of this invention are set forth below with
20 reference to the accompanying drawings:

Fig. 1 illustrates the cloning strategy used to isolate the HIV-1 envelope gene (env) from the E. coli plasmid pNA2. The hatched regions are HIV-1 DNA sequences and the open regions are from the cloning vectors. The
25 black region in the plasmid p1774 is constructed from synthetic oligonucleotides and was introduced as an SmaI--KpnI fragment into the SmaI-KpnI sites of plasmid p1614. The sequence of this synthetic oligonucleotide is shown.

Fig. 2 illustrates the strategy used to construct
30 the recombinant plasmid vector (p3046), which in turn is used to construct the baculovirus expression vector Ac3046. The plasmid pMGS3 contains sequences (cross-hatched areas) from the baculovirus AcNPV on either side of a cloning site at position 4.00. This site has the unique restriction
35 endonuclease sites for SmaI, KpnI, and BglII. The AcNPV polyhedrin promoter is in the 5' direction from the 4.00 position. The sequence

5'-TAATTAATTAA-3' is in the 3' direction, and has a translational termination codon in all three reading frames. The plasmid p1774 and the sequence of the synthetic oligonucleotide region is as described in Fig. 1. The
5 plasmid p3046 contains all of pMGS3 except for the sequences between the SmaI and BglII sites, where the HIV-1 envelope gene of p1774 is inserted.

Fig. 3 shows the nucleotide sequences of the DNA flanking the Ac3046 gp160 coding sequences. The 3046 env DNA
10 sequence between +1 and +2264 is shown in Fig. 4.

Figs. 4a-4k show the actual DNA sequence of the HIV-1 env gene segment along with the synthetic oligonucleotide sequences at the 5' end of the env gene in Ac3046 (between +1 and +2264). The locations of restriction endo-
15 nuclease sites are listed above the DNA sequence and the predicted amino acid sequence is listed below the DNA sequence. The bases are numbered on the right and on the left.

Figs. 5a-5d compare the DNA sequences of the env gene from Ac3046 with a published env gene sequence from
20 LAV-1. The LAV-1 sequence is on the top and Ac3046 is on the bottom. A line (1) below the LAV-1 sequence indicates that the sequence in Ac3046 is the same in this position. The DNA sequence numbering used is that described by Wain-
25 Hobson, et al., Cell, 40:9-17 (1985) for LAV-1.

Fig. 6 shows the ELISA end point dilution titers of human HIV-1 antibody positive sera (top graph) and rhesus monkey sera (bottom graph) from animals immunized with gp160 (IJ55, KL55) or gp120 (AB55, CD55, GH55). The ELISA titers
30 were measured against highly purified gp120 and gp160 proteins. The specifically bound antibody was measured with a goat anti-human IgG HRP conjugate. The highest dilution of serum that gives a positive response in the test is the titer.

35 Fig. 7 is a Table summarizing the gp160 Vaccine-induced immune responses of vaccinated seropositive patients.

Fig. 8 (A and B) shows vaccine-induced antibody responses directed against specific HIV envelope epitopes.

Fig. 9 shows the vaccine-induced T-cell proliferative responses to gp160 in vaccinated seropositive individuals.

Fig. 10 (A-C) shows the lymphocyte proliferation responses associated with vaccination.

Fig. 11 is a graph showing the percent change in CD4 cells in responders and non-responders over time.

10

SUMMARY OF THE INVENTION

It has been discovered that recombinant HIV-1 gp160 envelope protein ("rgp160"), especially when adsorbed onto an adjuvant such as alum (e.g., aluminum phosphate) is particularly useful as an AIDS vaccine. One aspect of this invention is an AcNPV expression vector having the coding sequence for a portion of the HIV-1 envelope gene which encompasses the amino acids 1-757 found in the recombinant clone No. 3046. Another aspect of the invention is the production of that recombinant HIV-1 envelope protein (and the protein itself) in insect cells -- especially the rgp160 protein coded for by the amino acid sequences 1-757 (i.e., 03046).

Other aspects of this invention comprise purification and formation of recombinant envelope protein particles from the gene product of the recombinant baculovirus that produces the 3046 protein and adsorption of the 3046 particles to aggregates of aluminum phosphate.

The invention also comprises prophylactic and/or therapeutic vaccines for AIDS or HIV infection and methods of preventing or treating AIDS or HIV infection.

DETAILED DESCRIPTION OF THE INVENTION

The following examples illustrate the invention without limiting its scope.

The recombinant baculovirus Autographa californica nuclear polyhedrosis virus (AcNPV) which contains a truncated HIV-1 gp160 gene coding for amino acids 1-757 of

the HIV envelope protein (recombinant Ac3046) is described in copending, coassigned U.S. application Serial No. 920,197 (now Serial No. 585,260). The cloning steps employed to construct the recombinant baculovirus-containing genes or portions of genes from HIV-1 are also disclosed there and are incorporated by reference.

The following is a detailed description of the genetic engineering steps used to construct the Ac3046 expression vector. The materials employed, including enzymes and immunological reagents, were obtained from commercial sources. Examples showing how to make and use the invention are also provided.

Other recombinant envelope proteins, referred to collectively as rgp160, are also contemplated, and include recombinant gp120 and gp41 proteins. Ac3046 is just one example of an expression vector and recombinant envelope protein according to the invention.

EXAMPLE 1

Construction of the baculovirus recombinant Ac3046 bearing the HIV-1 coding sequences for amino acids 1-757

Cloning and expression of foreign protein coding sequences in a baculovirus vector requires that the coding sequence be aligned with the polyhedrin promoter and upstream sequences on one side and with baculovirus coding sequences on the other side. The alignment is such that homologous recombination with the baculovirus genome results in transfer of the foreign coding sequence aligned with the polyhedrin promoter and an inactive polyhedrin gene.

Accordingly, a variety of insertion vectors were designed for use in HIV envelope gene constructions. The insertion vector MGS3, described below, was designed to supply the ATG translational initiating codon. Insertion of foreign sequences into this vector must be engineered such that the translational frame established by the initiating codon is maintained correctly through the foreign sequences.

The insertion vector MGS3 was constructed from an EcoRI-I restriction fragment clone of DNA isolated from a

plaque purified AcMNPV isolate (WT-1). MGS3 was designed to consist of the following structural features: (a) 4000 bp of sequence upstream from the ATG initiating codon of the polyhedrin gene; (b) a polylinker introduced by site-directed mutagenesis, which consists of an ATG initiating codon at a position of the corresponding polyhedrin codon, and restriction sites SmaI, KpnI, BglII and a universal stop codon segment; (c) 1700 bp of sequence extending from the KpnI restriction site (which is internal to the polyhedrin gene) through to the terminal EcoRI restriction site of the EcoRI-I clone. See, e.g., Fig. 2.

EXAMPLE 2

Construction of baculovirus recombinants bearing LAV env coding sequences

A recombinant plasmid designated NA2 (Fig. 1) consists of a 21.8 kb segment of an entire HIV-1 provirus inserted into pUC18. This clone was reportedly infectious since it could produce virus following transfection of certain human cells. Adachi, et al., J. Virol. 59:284-291 (1986). The complete envelope gene sequences contained in NA2 were derived from the LAV strain of HIV. Barre-Sinoussi (1983).

The HIV-1 envelope gene was isolated and engineered as described below, and as shown in Fig. 1. The envelope gene was initially isolated from NA2 as a 3846 bp EcoRI/SacI restriction fragment and cloned into the EcoRI/SacI restriction site pUC19. The resultant plasmid was designated p708.

The envelope gene was subsequently reisolated as a 2800 bp KpnI restriction fragment and cloned into the KpnI restriction site of pUC18. The resulting clone was designated p1614.

The KpnI restriction fragment in p1614 contained a slightly truncated piece of the HIV envelope gene such that 121 bp of the N-terminal corresponding sequence was missing. This missing part in the gene, which included the signal peptide sequences, was replaced by insertion of a

double-stranded synthetic oligomer. The inserted oligomer was designed from the LAV amino acid sequence using preferred polyhedrin gene codon usage. To facilitate further manipulation, a new SmaI restriction sequence was
5 concomitantly introduced in place of the ATG initiating codon. The ATG initiation codon will be supplied by the baculovirus insertion vector. The resultant plasmid was designated p1774.

Referring to Fig. 2, restriction fragments from
10 p1774 containing coding sequences of various domains of the HIV-1 envelope were cloned into the MGS insertion vectors (e.g., MGS3) such that the ATG initiating codon of the insertion vector was in-frame with the codons of the envelope gene. Construct p3046 consisted of the SmaI/BamHI
15 restriction fragment isolated from p1774 inserted into the SmaI/BglIII site of the plasmid vector pMGS3. This clone contains sequences coding for amino acids 1 through 757 of gp160 and uses a termination codon supplied by the MGS3 vector.

20

EXAMPLE 3

Preparation and Selection of Recombinant Baculovirus

The HIV env gene recombination plasmid p3046 was calcium phosphate precipitated with AcMNPV DNA (WT-1) and
25 added to uninfected Spodoptera frugiperda cells. The chimeric gene was then inserted into the AcMNPV genome by homologous recombination. Recombinant viruses were identified by an occlusion negative plaque morphology. Such plaques exhibit an identifiable cytopathic effect but no
30 nuclear occlusions. Two additional successive plaque purifications were carried out to obtain pure recombinant virus. Recombinant viral DNA was analyzed for site-specific insertion of the HIV env sequences by comparing their restrictions and hybridization characteristics to wild-type
35 viral DNA.

EXAMPLE 4

Expression of HIV env from recombinant

baculoviruses in infected insect cells

Expression of HIV env sequences from the recombinant viruses in insect cells should result in the synthesis of primary translational product. This primary
5 product will consist of amino acids translated from the codons supplied by the recombination vector. The result is a protein containing all the amino acids coded for from the ATG initiating codon of the expression vector downstream from the polyhedrin promoter to the translational
10 termination signal on the expression vector (e.g., rgp160). The primary translation product of Ac3046 should read Met-Pro-Gly-Arg-Val at the terminus where Arg (position 4) is the Arg at position 2 in the original LAV clone. The Met-Pro-Gly codons are supplied as a result of the cloning
15 strategy.

EXAMPLE 5Nucleotide sequence of the gp160 insert and flanking DNA.

20 The nucleotide sequence of the gp160 insert and flanking DNA was determined from restriction fragments isolated from viral expression vector Ac3046 DNA. The sequencing strategy involved the following steps. The 3.9 kb EcoRV-BamHI fragment was purified by restriction
25 digestion of Ac3046 viral DNA. The Ac3046 viral DNA had been prepared from extracellular virus present in the media of cells being used for a production lot of vaccine.

As shown in Fig. 2, the 3.9 kb EcoRV-BamHI fragment consists of the entire gp160 gene and 100 bp of
30 upstream and about 1000 bp of downstream flanking DNA. Of this, the nucleotide sequence of the entire gp160 gene was determined, including 100 bp of upstream and 100 bp of downstream flanking DNA.

Briefly, the results of the sequencing revealed a
35 chimeric construct as predicted from the cloning strategy. The sequence of the gp160 was essentially as reported by Wain-Hobson, et al. (1985). The sequence of 2253 bases between the presumed translation initiation and termination

codons predicts 751 amino acid codons and 28 potential N-linked glycosylation sites. The estimated molecular weight of this rgp160, including the sugar residues, is approximately 145,000.

- 5 Sequence analysis of 200 bases of flanking DNA indicated correct insertion as shown in Figs. 3, 4 and 5.

EXAMPLE 6

Amino Acid Sequence of gp160

- 10 Using standard automated Edman degradation and HPLC procedures, the N-terminal sequence of the first 15 residues of gp160 was determined to be identical to that predicted from the DNA sequence. The N-terminal methionine is not present on the gp160 protein. This is consistent
15 with the observation that AcNPV polyhedrin protein is also produced without an N-terminal methionine. A summary of the actual gp160 DNA and N-terminal protein sequences, as has been determined by analysis of the AcNPV 3046 DNA and purified gp160, is as follows (Table 1).

20

TABLE 1

LAV env gene in the AcNPV 3046 expression vector

Residue		2	3	4	5	6	7	8	9	10	11	12	13	14	
25		Pro	Gly	Arg	Val	Lys	Glu	Lys	Tyr	Gln	His	Leu	Trp	Arg	Trp
	Gly														
	ATG	CCC	GGG	CGT	GTG	AAG	GAG	AAG	TAC	CAA	CAC	CTG	TGG	CGT	TGG
	GGC														

- 30 These results compare to the original LAV-1 clone as follows (Table 2).

TABLE 2

35 LAV env gene in the original LAV-1 clone

Residue	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Met	Arg	Val	Lys	Glu	Lys	Tyr	Gln	His	Leu	Trp	Arg	Trp	Gly
	ATG	AGA	GTG	AAG	GAG	AAG	TAT	CAG	CAC	TTG	TGG	AGA	TGG	GGG

40

EXAMPLE 7Purification of Recombinant gp160

One aspect of the present invention is the procedure used to extract and purify the recombinant HIV-1 envelope protein coded for in the Ac3046 expression vector. The recombinant HIV-1 envelope protein gp160 is produced in *S. frugiperda* cells during 4-5 days after infection with Ac3046. Purification of this rgp160 protein involves the steps:

1. Washing the Cells
2. Cell Lysis
3. Gel Filtration Chromatography
4. Lentil Lectin Affinity Chromatography
5. Dialysis

This example describes the purification of the recombinant gp160 from about 2×10^9 Ac3046 infected cells.

1. Washing the cells. Infected cells are washed in a buffer containing 50 mM Tris buffer (pH 7.5), 1 mM EDTA and 1% Triton X-100. The cells are resuspended in this buffer, homogenized using standard methods, and centrifuged at 5000 rpm for 20 minutes. This process is repeated 3 times.

2. Cell Lysis. The washed cells are lysed by sonication in 50 mM Tris buffer (pH 8.0-8.5), 4% deoxycholate and 1% beta mercaptoethanol. Sonication is done using standard methods. After sonication, only remnants of the nuclear membrane are intact and these are removed by centrifugation at 5000 rpm for 30 minutes. The supernatant containing the extracted gp160 has no intact cells, as determined by light microscopy observations.

3. Gel filtration. Gel filtration is done in a Pharmacia 5.0 x 50 cm glass column packed with a Sephacryl resin (Pharmacia). The total bed volume is about 1750 ml. To depyrogenate and sanitize the column and tubing connections, at least 6 liters of 0.1 N NaOH is run through the column over a period of 24 hours. The effluent from the

column is connected to a UV flow cell and monitor and a chart recorder (Pharmacia) and then is equilibrated with 4 liters of Gel Filtration Buffer. The crude gp160 is loaded onto the column and is developed with Gel Filtration Buffer.

5 The column separates the crude mixture into three major UV absorbing fractions. The first peak comes off between about 500 and 700 ml, the second between 700 and 1400 ml and the third between 1400 and 1900 ml buffer. This same profile is observed on small analytical columns from
10 which it has been determined that the first peak is material that has a molecular weight of $\geq 2,000,000$.

 This peak is translucent due to a concentration of high molecular weight lipids and lipid complexes. This peak also contains from 10% to 20% of the gp160 extracted from
15 the infected cells. Apparently this fraction of gp160 is complexed to itself or other cell components to form high molecular weight aggregates.

 The second broad peak contains the majority of the gp160 and proteins with molecular weights of between about
20 18,000 and 200,000.

 The third peak contains little protein and the majority of the UV absorption is due to the beta mercapto-ethanol in the sample.

 When the second peak is first detected from the
25 tracing of the UV absorbance, the effluent from the column is applied directly onto the lentil lectin column. Once the second peak has come off the column, the effluent is disconnected from the lentil lectin column and directed to waste.

30

4. Lentil Lectin. The lentil lectin affinity gel media (Lentil Lectin-Sepharose 4B) was purchased in bulk from Pharmacia. The lentil lectin was isolated by affinity chromatography on Sephadex to greater than 98% purity and
35 then was immobilized by coupling to Sepharose 4B using cyanogen bromide. The matrix contains about 2 mg ligand per ml of gel. The lentil lectin column is a 5.0 x 30 cm glass column (Pharmacia) containing 125 ml lentil lectin-Sepharose

4B gel. The affinity matrix is reused after being thoroughly washed and regenerated by a procedure recommended by the supplier. When not in use, the gel is stored in the column in a solution of 0.9% NaCl, 1 mM MnCl₂, 1 mM CaCl₂, and 0.01% thimerosal. The column is washed and equilibrated with 250 ml lentil lectin buffer described above before each use.

The crude gp160 is applied to the column directly as it is eluting from the gel filtration column as described above. Once the crude gp160 is bound to the column, it is washed with 800 ml lentil lectin buffer containing 0.1% deoxycholate. Under these conditions all of the gp160 binds to the column. Lentil lectin buffer plus 0.3M alpha-methyl mannoside is used to elute the bound glycoproteins which is monitored through a UV monitor at a wavelength of 280 nm.

15

5. Dialysis. Sugars and deoxycholates are removed by conventional dialysis.

The purification of gp160 from 1 liter of infected cells can be summarized in the following table (Table 3).

20

In another embodiment, conventional ion exchange chromatography (anionic or cationic) may be used in place of gel filtration. Similarly, the order of steps is not critical: For example, gel filtration or ion exchange chromatography may follow the lentil lectin purification step. Other reagents may also be used according to the invention. For example, other detergents may be used to purify the recombinant protein in place of deoxycholate. These include nonionic detergents such as Tween 20 (polysorbate 20), Tween 80, Lubrol, and Triton X-100.

30

35

TABLE 3 - Purification Summary

Purification Step	Total Protein (mg) ¹	gp160 Protein (mg)	%gp160 Total	Contaminants Removed
Cell Pellet	1-2000	20	1-2	Culture Medium
1,2,3rd Wash	250	15	6	Serum Albumin, most Nucleic Acids, and Soluble Cell Proteins
Gel Filtration	120	12	12	Lipids, Nucleic Acids, and high mol wt aggregates
Lentil Lectin	14	10	70	Nonglycosylated proteins
Dialysis	13	9	70	Sugar, deoxycholate, excess Tris buffer

EXAMPLE 815 A. Assembly of gp160 Particles.

As one aspect of the present invention, it has been discovered that the gp160 antigen can be assembled into particles of $\geq 2,000,000$ molecular weight during purification. The gp160 protein is extracted from the cell as a mixture of 80-90% monomeric (160,000 molecular weight) and 10-20% polymeric (particle form). The gel filtration step removes the aggregated forms of gp160. Attempts to purify the gp160 from this fraction (first peak off the gel filtration column) suggest that it is complexed with other cell proteins, possibly even with membrane fragments. However, the gp160 antigen in the second peak off the gel filtration column has a molecular weight of about 160,000-300,000 and is, therefore, in predominantly monomeric or dimeric form.

The formation of aggregates or polymers of gp160 occurs during the development of the lentil lectin column. It has been determined that the antigen forms aggregates whether it is eluted from the lectin column in 0.5% deoxycholate, which is about the 0.2% critical micelle con-

35 ¹ Total protein was estimated from absorbance at 280nm.

centration (CMC) for deoxycholate, or whether the gp160 is eluted from the column in 0.1% deoxycholate.

The size of the aggregates are measured on a high resolution FPLC Superose 12 column (Pharmacia). Samples from representative lots of purified gp160 have a size that is predominantly equal to or greater than the 2,000,000 molecular weight of a blue dextran size standard.

A cross-linking study by Schwaller, *et al.* (1989), demonstrated that gp160 produced in insect cells is a tetramer of identical subunits. The study also shows that gp160 in HIV-infected cells and virus particles is tetrameric. Thus, the recombinant gp160 particles may have tertiary and quaternary structures that are similar to those found in the native HIV gp160.

Proper 3-dimensional structure could be important for the formation of epitopes that require correct folding of gp160. It is likely that, as non-glycosylated proteins are removed from association with the gp160 antigen during the binding and washing to the lentil lectin column, the hydrophobic portions of gp160 begin to form intermolecular associations. The deoxycholate is probably not bound to the gp160 as the concentration can be kept above the CMC and the antigen will still form complexes. The assembly of this antigen into aggregates appears to be an intrinsic property of this protein once it is purified according to the invention. It is possible that the very hydrophobic N-terminal sequence that is present on the gp160 protein contributes to the natural ability of this protein to form particles. After purification, the gp160 complexes can be sterile filtered through a 0.2 micron cellulose acetate filter without significant loss of protein.

B. Analysis of Particle Formation.

An analysis of purified gp160 particles by electron microscopy demonstrates that they are protein-like, spherical particles of 30-100 nm.

As an additional test for the presence of particles, purified gp160 was analyzed by gel filtration.

About 100 micrograms of gp160 was applied to a Superose 12, FPLC gel filtration HR 10/30 column (Pharmacia, Inc.). This column was first calibrated with protein molecular weight standards. The protein profile from this column is highly reproducible; the elution volume is inversely proportional to the molecular weight of the protein standards. The column separates the monomeric gp160 from the polymeric forms and excludes globular proteins of $\geq 2 \times 10^6$ molecular weight. When developed on this column, essentially all of the purified gp160 elutes in the void volume and is, therefore, $\geq 2 \times 10^6$ (2,000,000) molecular weight in size.

EXAMPLE 9

A. Adsorption of gp160 to Alum.

The effectiveness of insoluble aluminum compounds as immunologic adjuvants depends on the completeness of adsorption of the antigens on the solid phase. As part of the present invention it was discovered that alum compositions could be made that would efficiently adsorb the gp160 but at a pH that would not reduce the potency of the gp160-alum complex as an immunogen. The factors controlled during the formation of this alum (aluminum phosphate gel) composition are:

1. The optimal pH for adsorption of antigens to alum is about 5.0. However, it was discovered that the gp160 lost immunogenicity at a pH of 6.5 in comparison to a pH of 7.5 so the alum is made at a pH of 7.1 ± 0.1 . It was discovered that essentially 100% of the gp160 will still adsorb to the alum at this pH.
2. The ionic strength from the NaCl present is relatively low and is less than 0.15 M.
3. There is a molar excess of aluminum chloride relative to sodium phosphate to assure that there is

an absence of free phosphate ions in the supernatant.

4. The gp160 antigen is added to freshly formed alum to stop crystal growth and minimize the size of the particles.

The procedure to make 200 ml alum and adsorb purified gp160 to the alum is such that the final concentration of antigen is 40 $\mu\text{g/ml}$, as outlined below.

B. Preparation of Reagents (200 ml total formulated lot).

Prepare the following solutions in 100 ml sterile, pyrogen-free bottles or beakers. Mix the salts for Solution 1 and Solution 2 and the sodium hydroxide and filter through 0.2 micron cellulose acetate filters into 100 ml sterile, pyrogen-free bottles.

20	Solution 1	$\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$	0.895 grams
		$\text{NaHAc} \cdot 3\text{H}_2\text{O}$	0.136 grams
		Dissolve in 40 ml water for injection (WFI), 0.2 micron filter	
	Solution 2	$\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$	1.234 grams
		Dissolve in 40 ml WFI, 0.2 micron filter	
	Solution 3	NaOH	2.0 grams
		Dissolve in 100 ml WFI, 0.2 micron filter	
25	Solution 4	Tris	1.25 grams
		Dissolve in 100 ml WFI, add 1 ml to 90 ml WFI, adjust pH to 7.5 with 0.5N HCl, and bring to 100 ml with WFI	

Autoclave the solutions for 30 min; slow exhaust. Cool to room temperature.

30 C. Formation of Alum

1. Add Solution 1 (aluminum chloride-sodium acetate to the formulation vessel using 25 ml sterile,

disposable pipets. Note the volume of Solution 1 and begin stirring the solution.

- 5 2. Add Solution 2 (sodium phosphate) to the vessel using 25 ml sterile, disposable pipets and continue stirring as the precipitate forms and note the volume of Solution 2.
- 10 3. Add 3 ml Solution 3 (sodium hydroxide) and continue stirring for 5 min. Take a 0.5 ml sample and measure the pH. If the pH is less than 7.0, add an additional 0.5 ml sodium hydroxide, stir for another 5 minutes and measure the pH again. Continue until the pH is between 7.0 and 7.2.
- 15 4. Determine the total volume added to the formulation vessel (Solution 1 + Solution 2 + Solution 3), then add sterile WFI to bring the volume to 100 ml.
- 20 5. Immediately add 8,000 micrograms of purified gp160 in 100 ml of 1 mM Tris pH 7.5 directly into the formulation vessel.
- 25 6. Continue stirring for a minimum of 20 minutes, then dispense the formulated vaccine into sterile vials.

EXAMPLE 10

Immunogenicity of Alum Absorbed gp160 (Specific Ab Response)

- 30 An accepted method to determine the immunogenicity of an antigen preparation (vaccine) is to measure the specific antibody response in groups of mice which have been given a single dose of antigen. At the end of 4 weeks the mice are bled and the serum antibody levels to a specified
- 35 antigen (usually the antigen used to immunize the animal) are measured by a standard antibody test, e.g. an ELISA (enzyme linked immunosorbent assay).

The immunogenicity in mice of purified gp160 with no adjuvant at pH 6.0 and pH 7.5 adsorbed with alum (as described in Example 9) or mixed with Freund's Complete Adjuvant are summarized below (Table 4).

5

TABLE 4

Group		gp160 Mean ELISA		Seroconversion		
	gp160	Adjuvant	Lot#	OD ²	% (P/N) ³	
10	1 μg	None, pH 7,5	8702	0.140	57%	4/6
		None, pH 6.0	8702	0.110	26%	2/7
		Alum	8702	1.000	90%	9/10
		Alum	8705	2.285	100%	6/6
15	0.1 μg	Freund's	8604	1.108	83%	5/6
		Freund's	8702	1.396	100%	7/7
		Freund's	8604	0.434	67%	4/6
		Alum	8705	1.003	67%	4/6

20

Mice immunized with a single 1.0 microgram dose of gp160 antigen without any added adjuvant will elicit an antibody response against gp160 (see table above). However, a much stronger antibody response is seen in groups of mice immunized with 1.0 microgram of gp160 adsorbed to the alum

25

adjuvant. A single dose of less than 0.1 microgram of gp160 mixed with complete Freund's or formulated with alum will seroconvert \geq 50% of the immunized mice. Although less so, the gp160 antigen was immunogenic in mice as an unformulated antigen at pH 7.5 and at pH 6.0, but there was a loss of

30

immunogenicity at the lower pH.

² The mice were bled 28 days post immunization and the sera tested at 1:10 dilution in an ELISA assay against gel-purified gp160. Similar results were obtained using a commercial ELISA (Genetic Systems Inc.; EIA[™] ELISA) assay against the native HIV-1 proteins at a serum dilution of 1:400.

35

40

³ The number of seroconverted mice (P) to the total number tested (N).

EXAMPLE 11Immunogenicity of Alum Adsorbed gp160 (ELISA Serum Study)

5 The ability of a candidate vaccine to elicit an immune response is a very important biological property. To confirm that the alum formulated gp160 vaccine was immunogenic in animals and to confirm that the alum adjuvant increased this immunogenicity, the following experiment was performed.

10 On day 0, mice (groups of 10) were injected with a single dose (0.5 micrograms, 1.0 micrograms, or 5.0 micrograms) of gp160 alone, gp160 adsorbed to alum or gp160 in complete Freund's adjuvant (CFA). On day 28 the mice were bled and the sera examined by ELISA (1:10 dilution) for
15 the presence of antibodies to gp160.

Results from the sera drawn on day 28 are summarized in the table below (Table 5). In all groups, greater than 50% of the mice showed seroconversion. At all doses the number of sero-conversions and the average serum
20 absorbance (OD_{450} nm at a 1:10 dilution in the ELISA assay) were higher with gp160 adsorbed to alum than those obtained in mice immunized with gp160 alone.

These results demonstrate that the alum adjuvant significantly increased the immunogenicity of the gp160
25 antigen.

30

35

TABLE 5 - 28 Days Post-Injection

	0.5 μ g Dose		1.0 μ g Dose		5.0 μ g Dose	
	<u>Mean</u>		<u>Mean</u>		<u>Mean</u>	
	<u>P/N</u> ⁴	<u>OD</u> ⁵	<u>P/N</u>	<u>OD</u>	<u>P/N</u>	<u>OD</u>
gp160	9/10	.407	7/10	.699	7/10	.430
gp160 (alum)	9/10	.547	8/10	.797	10/10	1.347
gp160 (CFA)	10/10	1.130	10/10	1.967	10/10	1.317

EXAMPLE 12Neutralization Data

HIV-1 neutralization assays are an accepted method to determine whether an antibody preparation will inhibit the HIV-1 virus from infecting susceptible human cultured lymphocyte cells. Antisera from animals immunized with gp160 were tested in an HIV-1 neutralization assay and the results are summarized in the table below (Table 6).

⁴ The number of mice that seroconverted (P) compared to total number tested (N) at 28 days after being immunized with 0.5 micrograms, 1 micrograms or 5 micrograms of VaxSyn[™] HIV-1.

⁵ The mean absorbance (OD₄₅₀) of the mice that seroconverted as measured by the sponsor's ELISA assay against gp160 at a 1:10 dilution of serum.

TABLE 6

Animal	Identification	Immunogen/ Adjuvant	Micrograms ⁶	Neutraliz- ing Titer ⁷
Rhesus	G55	gp120/Alum	16/8/8	1:80-1:160
Rhesus	H55	gp120/Alum	16/8/8	1:80-1:160
5 Rhesus	L55	gp160/Alum	16/8/8	≥ 1:80
Mice	Pool 3	gp120/Freund's	.25/.25/.25	1:40-1:80
Mice	Pool 8	gp160/Freund's	.1/.1/.1	1:40-1:80
G. Pig	Purified IgG	gp160/Freund's	10/10/10	1:320

10 Guinea pigs, rabbits and rhesus monkeys have also
 been immunized with gp160 (using alum or Freund's as an
 adjuvant). In general, the immunization of these animals
 has produced a good antibody response against the HIV-1
 envelope proteins.

15

EXAMPLE 13Immunogenicity in Chimpanzees

Genetically, the chimpanzee is man's closest rela-
 tive and is currently the only animal model for infection of
 20 HIV-1. In a safety/immunogenicity trial in three
 chimpanzees, two chimpanzees were immunized with 40
 micrograms or 80 micrograms of gp160 in an alum formulated
 vaccine. Each received a booster immunization at 4 weeks
 with 40 micrograms and 80 micrograms of gp160, respectively.
 25 A control animal was vaccinated at the same time with a 1 ml
 saline solution. Weekly serum samples were analyzed from
 each of the three chimpanzees for antibodies to gp160 and to
 HIV-1 viral antigens using three immunological assays, an
 ELISA assay against purified gp160 developed by

30 ⁶ Micrograms of gp160 or gp120 administered during the
 first/second/third immunization.

35 ⁷ The highest dilution of antisera that will inhibit the
 infection by 50% relative to HIV-1 infected cells that were
 exposed to serum from non-immunized animals.

MicroGeneSys, Inc., Western Blot analysis, and a commercial HIV-1 ELISA assay. The results of these analyses are described below.

5 A. ELISA (MGSearch HIV 160)

The ELISA assay, MGSearch HIV 160, MGSearch being a trademark of MicroGeneSys, Inc. of Meriden, Connecticut, U.S.A., is an immunosorbent assay against gp160 and is described in copending coassigned U.S. patent Application
10 Serial No. 920,197 (now No. 585,266).

Serum samples taken before immunization and for the 11 weeks following the primary immunization were diluted from 1:10 to 1:100,000 and then incubated with nitrocellulose strips containing a 100 μ g purified gp160 in
15 a spot. The end point dilution titer is the highest dilution in which the test was positive for anti-gp160 antibody as detected with a goat anti-human IgG-alkaline phosphatase conjugate.

The serum samples from the control animal and from
20 the pre-immune sera of the immunized animal were negative. The chimp which received the 80 microgram dose was positive at a 1:100 dilution by week 2 and the chimp which received a 40 microgram dose was positive at a 1:10 dilution by week 4. The antibody titers to gp160 continued to increase until
25 week 5, at which time the end point dilution titers were approximately 1:100,000 and 1:2,000,000 respectively. The antibody titer in both animals dropped just slightly during weeks 6-11.

This type of response is similar both
30 quantitatively and qualitatively to antibody responses commonly observed in chimps that have been vaccinated with a human Hepatitis B Virus vaccine.

B. Commercial ELISA Test

It was clear from the MGSearch HIV 160 ELISA and
35 Western blot analyses of sera from the VaxSyn⁸ immunized

⁸ VaxSyn is a trademark of MicroGeneSys, Inc. for the AIDS vaccine described herein.

chimpanzees, that they had seroconverted and have antibodies against the recombinant gp160. To determine if they were also making anti-HIV antibody which recognized the native viral envelope proteins, the pre-immune sera and sera from 5 weeks 1 through 11 were tested in a licensed, commercial ELISA test kit, the LAV EIA™ test kit of Genetic System Corporation, Seattle, Washington. The animal immunized with 80 micrograms of gp160 was positive at a 1:100 dilution by week 2 and continued to show an increase in antibody level 10 through week 6. The animal immunized with 40 micrograms was positive at a 1:100 dilution by week 6.

EXAMPLE 14

Distribution of Antibodies Between gp120 and gp41

15 It is important to determine whether the antibody responses against gp160 in a vaccinated animal is directed against gp41, gp120 or both. A variety of immunological methods, including radioimmunoprecipitation (RIP), immuno-
20 fluorescence (IF), Western blot analysis (WB), and quantitative ELISA against three different recombinant envelope antigens were employed to detect and measure for the distribution of antibodies against various regions of the HIV-1 envelope proteins.

Fig. 6 summarizes the immunoreactivity of three
25 different recombinant antigens: [ART] [TAB] (1) gp120-delta (truncated recombinant HIV-1 gp120 with about 40 amino acids missing from the C-terminus of the molecule); [ART] [TAB] (2) gp120 (full length recombinant HIV-1 gp120; and [ART] [TAB] (3) gp160.

30 Human sera from 50 HIV-1 antibody positive individuals and 3 pooled human sera were highly reactive with gp160, moderately reactive with gp120 and little or no antibody reacted with truncated gp120. It is likely that the truncated gp120, which represents more than 90% of the
35 HIV-1 external glycoprotein, contains protective determinants. The observation that human AIDS positive sera have few antibodies to this region of the envelope is consistent with the fact that the immune response to viral infection is

not fully protective and that human positive sera usually exhibit a low-level of neutralizing activity in vitro.

In contrast, rhesus monkeys immunized with either the gp160 immunogen or with the truncated gp120 have
5 antibodies that react strongly with the truncated gp120 portion of the HIV-1 envelope. This difference in distribution of antibody recognition sites along the viral envelope and the higher titers observed in the monkeys may account for the fact that the monkey sera had high neutralizing
10 titers.

A quantitative assessment of the immunoreactivity of these three recombinant envelope antigens with human and immune rhesus sera is presented in Fig. 7. All the monkey sera tested had high titer antibody against the truncated
15 gp120 antigen (gp120-delta), including those from animals immunized with gp160.

These results demonstrate that the recombinant gp160 elicits an antibody response in rhesus monkeys that is different than what often occurs during natural infection.
20 There are epitopes in the gp120-delta region of gp-160 that are efficiently recognized in the immunized monkeys that are not seen by the human immune system during infection. These new epitopes may be important for protection against HIV-1, and could be an important property of the recombinant gp160
25 for prevention and treatment of HIV-infection.

EXAMPLE 15

Therapeutic Vaccine Administration

A clinical trial with 30 HIV-seropositive human
30 patients was conducted to determine the effects of vaccination with cloned HIV gp160 (produced in the baculovirus system as described above) on HIV infected individuals.

Vaccination with the recombinant gp160 led to an augmentation in the gp160 HIV-specific humoral and cellular
35 immune responses of 19 out of 30 (63%) HIV seropositive volunteers. Fourteen out of 15 (93%) volunteers receiving 6 doses of the vaccine demonstrated an increase in their total gp160 antibody. Therefore, recombinant HIV proteins

(i.e., rgp41, rgp120, rgp160 and admixtures thereof) can be advantageously administered in a method to treat a human patient infected by HIV.

The effective amounts of HIV protein used in this embodiment of the invention can be determined according to techniques well known in the art, such as those presented below. In general such effective amounts may range between about 1 microgram and about 100 micrograms per kilogram body weight of the patient. The frequency of administration can also be determined by known means. In a preferred embodiment, administration is via the parenteral route, i.e., intravenously, intraperitoneally, intramuscularly, intradermally, etc., as is well known by those of ordinary skill in the art.

A. Volunteer Selection

Thirty volunteers with HIV infection were recruited. Only seropositive volunteers with early stage HIV infection, defined as Walter Reed Stage 1 or 2 (CD4 cell count not less than 400 for greater than 3 months, with or without lymphadenopathy) were eligible for enrollment. (Redfield, et al., New Engl. J. Med. 314: 131-132 (1986). Additional entry criteria limited volunteers to adults between the ages of 18 and 50, with a normal complete blood count, no evidence of end organ disease, no alcohol or drug abuse over the preceding 12 months, and who were not receiving anti-retroviral or immunomodulatory drugs. All patients underwent a 2 month baseline evaluation prior to randomization into treatment groups. No volunteers received any antiretroviral or immunomodulatory drugs during the trial.

Twenty-six of the 30 volunteers were men; 4 were women. Fourteen were Caucasian, 13 Black, and 3 Hispanic. The mean age was 29 (range 18-49). At enrollment 8 volunteers were Walter Reed Stage 1 and 22 volunteers were Walter Reed Stage 2. The baseline mean CD4 count was 668 (range 388-1639). The mean time between initial diagnosis and study entry was 24 months (range 3 months to 49 months).

B. Vaccine Product and Immunization Schedule

As described herein, the test vaccine comprises a non-infectious subunit glycoprotein derived from gp160 as a baculovirus expressed recombinant protein. The immunogenic protein was produced in Lepidopteran insect cells, was biochemically purified, and was adsorbed to aluminum phosphate for final vaccine formulation.

Three dose formulations of gp160 were used: 40 micrograms per milliliter, 160 micrograms per milliliter and 320 micrograms per milliliter. The injection volume for both the 40 μ g and 160 μ g dosages was 1 ml; 2 ml of 320 μ g per milliliter was used to deliver the 640 μ g dose injections.

The thirty volunteers were distributed into six groups of five volunteers each. Two immunization schedules were investigated: Schedule A, with vaccination on days 0, 30, and 120; and Schedule B, with vaccination on days 0, 30, 60, 120, 150 and 180. Within each immunization Schedule (A or B) there were three groups which received different dosages of vaccine (Table 7 below). All vaccinations were administered by intramuscular injection into the deltoid muscle. The duration of the trial was 10 months: a 2 month baseline evaluation, and an 8 month follow-up evaluation after the initial vaccination.

TABLE 7 - Immunization Schedule

		Amount of gp160 Administered (μ g)					
		Day 0	30	60	120	150	180
<u>Schedule A</u>							
	Group 1	40	40		40		
	Group 3	160	160		160		
	Group 5	640	640		640		
<u>Schedule B</u>							
	Group 2	40	40	40	160	160	160
	Group 4	160	160	160	640	640	640
	Group 6	640	640	640	640	640	640

C. Assessment of Safety and Toxicity

Each volunteer was interviewed and examined on days 0, 1, 2, 3, 15 and 30 after each injection. Volunteers were queried concerning fever, chills, nausea, vomiting, arthralgia (painful joints), myalgia (muscular pain), malaise, urticaria (hives), wheezing, dizziness, or headache. Examinations to assess local reactions at the site of injection included erythema, swelling, itching, pain and tenderness, skin discoloration, skin breakdown, change in regional lymphadenopathy, change in function of the injected extremity, and subcutaneous nodule formation at the site of injection. Monthly complete blood counts, serum chemistries, coagulation profile and urine analysis were also assessed.

In vitro cellular immune function was assessed by T-cell phenotyping (total lymphocyte, CD4 and CD8 cell phenotypes) as described in Rickman, et al., Clinical Immuno. 52: 85-95, 1989; Birx, et al., J. Acquir. Immune Defic. Syndr. 4: 188-196, 1991). T-cell proliferative response to mitogens (pokeweed and Con A) and control antigens (Candida albicans and tetanus) was also evaluated. Birx et al, supra. In vivo cellular immune function was assessed by delayed hypersensitivity skin testing to control antigens (i.e., mumps, tetanus toxoid, Candida albicans and trichophyton).

Quantitative viral cultures of peripheral blood mononuclear cells (PBMC) and plasma were assessed as described in Burke, et al., J. Acquir. Immune Defic. Syndr. 3: 1159-1167, 1991. DNA polymerase chain reaction (Wages, et al., J. Med. Virol. 33: 58-63, 1991) and serum p24 antigen levels were assessed to monitor in vivo HIV viral load.

No evidence of systemic toxicity was observed, but local reactogenicity was noted in 87 percent of the subjects (13 in each vaccination group). Local reactions included induration, tenderness, and transient subcutaneous nodule formation at the injection site; an increase in regional adenopathy was rarely noted. No subject refused a booster

injection. No difference in the frequency of local reactions was observed for primary immunization, booster injection, or dosage.

No evidence of adverse effects on the immune system was demonstrated as measured in vitro by mitogen and antigen specific proliferative responses, in vivo by delayed hypersensitivity skin testing responses, or by acceleration of quantitative CD4 cell depletion. Baseline mean CD4 cell counts were 716 and 605 for vaccine responders and non-responders, respectively. Mean CD4 cell counts from study days 180-240 were 714 and 561, for vaccine responders and non-responders, respectively. During the course of the 240-day trial, the net change in mean CD4 cell counts for vaccine responders was a minus 0.2 percent, while among vaccine non-responders the mean CD4 cell count declined by 7.3 percent (Figure 11). Vaccine induced HIV immunogenicity was not associated with evidence of accelerated CD4 decline in any individual subject throughout the entire course of the trial.

To assess the possibility of increased HIV replication and viral load in subjects as a consequence of vaccination, in vivo viral activity was measured by quantitative plasma and PBMC viral cultures, PBMC DNA polymerase chain reaction, and serum levels of p24 antigen. Quantitative cultures and DNA polymerase chain reaction assays demonstrated no alteration during this trial. Serum p24 antigen was undetectable in the subjects.

D. Assessment of Immunogenicity

Antibodies directed against whole HIV proteins were measured using both recombinant produced viral gene products gp160, p66, p24 and whole viral lysate of prototype HIV strain MN. Dot blot and Western Blot techniques were used, as described in Toubin, et al., Proc. Natl. Acad. Sci. USA 76: 4350-4354 (1979). Antibody responses to specific envelope epitopes were also measured (see Fig. 7).

In Fig. 7 epitopes 88 (amino acids 88-98 in gp120) and 448C (amino acids 448-514 in gp120) were selected

because antibody directed against these regions of gp120 are reported to correlate with early stage HIV infection.

Epitopes 106 (amino acids 106-121 in gp120), 241 (amino acids 241-272), 254 (amino acids 254-272), 300 (amino acids 300-340), 308 (amino acids 308-322), 422 (amino acids 422-454) and 735 (amino acids 735-752) were selected because of their putative functional importance. Epitopes 106 and 422 have been implicated in CD4 binding; epitopes 241, 254 and 735 have been implicated in group specific neutralization; and epitopes 300 and 308 have been implicated in type-specific neutralization).

Epitope 582 (amino acids 582-602) was selected as a control because it represents the immunodominant envelope domain in natural HIV infection. Additional epitopes investigated included 49 (amino acids 49-128); and 342 (amino acids 342-405).

In Fig. 7, a shaded box signifies a documented change in the HIV envelope-directed immune response. Shaded boxes with (=) signify a primary humoral response; shaded boxes with (+) signify a secondary humoral response; (-) signifies antibody negative to specific epitope pre and post immunization; and a (+) signifies antibody positive to specific epitope pre and post immunization, but without a quantitative change. Shaded boxes with (.) signify new T-cell proliferative response to gp160 following immunization. A (.) alone signifies no cellular response to gp160; while hb signifies "high background" (not interpretable); and nd signifies "not done."

Neutralization activity was measured against three prototype isolates (HIV-IIIB, RF and MN) in a syncytium inhibition assay as described in Nara, Nature, 333:469-470 (1988). HIV specific cellular responses were measured by known lymphocyte proliferation assay techniques using gp160, p24 and baculoviral expression system control protein (Birx, supra).

E. Vaccine Responders and Non-Responders

Subjects were classified as vaccine responders only if a reproducible selective increase of both a cellular and humoral immune response against HIV envelope specific epitopes were associated with the vaccination series (Fig. 7). Vaccine induced humoral immunity was defined as seroconversion to HIV envelope specific epitopes and/or a secondary booster immune response to envelope specific epitopes. Vaccine induced cellular immunity was defined as the development of a new, reproducible, vaccine associated, proliferative response to gp160.⁹ Subjects who developed neither a humoral nor a cellular proliferative response or who developed only a humoral or only a cellular proliferative response to gp160 epitopes or HIV envelope were classified as non-responders.

F. Vaccine Induced Humoral Responses

Referring to Fig. 7, 19 of the 30 subjects (63 percent) demonstrated a vaccine induced augmentation of both gp160 HIV specific humoral and a cellular immune responses. These 19 were classified as "vaccine responders". Four of the 11 "non-responders" developed only a humoral or a cellular immune response. All 7 subjects who failed to demonstrate any detectable vaccine induced response received only 3 doses (Schedule A). No changes in antibody binding to HIV polymerase (p66), or structural (p24) gene products or the non-HIV control antigen tetanus were detected. No anti-baculoviral Lepidopteran cell control protein antibody developed in any subject.

Increases in envelope antibody (gp160) were detected in 13 subjects by Western Blot using the whole virus lysate HIV-MN. The changes were related to the immunization schedule. Three of 15 subjects (20 percent) on Schedule A, and 10 of 15 subjects (67 percent). Schedule B

⁹ This definition of a vaccine responder is highly restrictive in light of the scientific objectives of this trial: e.g., to assess the feasibility of post-infection immunization.

developed an antibody increase to envelope proteins ($P=0.025$ by Fisher's exact test, two-tailed). All 13 subjects also seroconverted to specific envelope epitopes.

Conversely, of the 10 subjects who failed to seroconvert to any envelope specific epitope, none exhibited an increase in envelope antibody by Western Blot. The remaining 7 subjects who seroconverted to specific envelope epitopes demonstrated no change in whole virus envelope antibody by Western Blot. No changes in antibody directed against non envelope HIV proteins were observed in any subject.

Fourteen of 15 subjects (93 percent) on Schedule B (6 doses) demonstrated an increase in total gp160 antibody, as opposed to only 7 of 15 subjects (47 percent) on Schedule A (3 doses) ($P=0.01$ Fisher's, two-tailed). (Fig. 7).

As shown in Fig. 8, the pre-immunization to post-vaccination prevalence of each gp160 specific epitope respectively was as follows: Epitope 49 (27 to 70 percent), Epitope 88 (28 to 52 percent), Epitope 106 (50 to 87 percent), Epitope 214 (0 to 14 percent), Epitope 254 (0 to 13 percent), Epitope 300 (47 to 77 percent), Epitope 308 (42 to 69 percent), Epitope 342 (0 to 27 percent), Epitope 422 (3 to 10 percent), Epitope 448C (73 to 87 percent), and Epitope 735 (17 to 33 percent). Vaccine induced seroconversion was noted against all of the specific epitopes except 582 (Fig. 7). Antibodies (seroconversion) directed against Epitopes 241, 254 or 342 were only detected following vaccination.

Secondary immune responses were detected to the following epitopes: 88, 106, 300, 448C, and 582. The prevalence of antibody directed against epitope 582 was 100 percent pre-vaccination and only one subject (3 percent) demonstrated a secondary immune response.

The pattern of vaccine induced HIV antibody to envelope epitopes was variable (Fig. 7). Primary antibody responses (seroconversion) to at least one epitope occurred in 20 subjects; 14 of 15 receiving Schedule B, and 6 of 15

randomized to Schedule A ($P=0.005$ Fisher's, two-tailed). Schedule A subjects seroconverted to only 15 of 110 (14 percent) of the potential epitopes to which they had no preimmunization antibodies. Schedule B subjects
5 seroconverted to 60 of 129 (47 percent) ($P<0.0001$ Fisher's, two-tailed). Seroconversion to three or more envelope epitopes occurred in 9 subjects (60 percent) randomized to Schedule B but only 2 subjects (13 percent) randomized to Schedule A ($P=0.02$ Fisher's, two-tailed).
10 Serum neutralization activity against three distinct strains (HIV-IIIB, MN, and RF) was determined on days 0, 90 and 195 in 7 subjects. Four of 5 vaccine responders demonstrated increasing neutralizing activity to one or more isolate. The vaccine responders also demon-
15 strated an increased ability to inhibit syncytium formation compared to non-responders.

G. Vaccine Induced Cellular Responses

Changes in cellular immune response were based on
20 a comparison of mean pre-vaccination (baseline) and post-vaccination lymphocyte stimulation indices (LSI) using a Wilcoxon rank sum test.

Twenty-one of 30 subjects (70 percent) developed a new T cell proliferative response to gp160 post-immuniza-
25 tion (Fig. 7).

Figure 9 illustrates proliferative responses to gp160, p24 and a baculovirus control protein in four typical vaccine responders over time. For all subjects the gp160 induced proliferation increased from a baseline mean LSI of
30 3 to an LSI of 10 (calculated utilizing the mean of 4 values following the last immunization). In contrast, no change was noted for proliferative responses directed against HIV p24 protein or the control baculovirus protein.

Vaccine induced changes in mean LSI values for all
35 subjects, for subjects subgrouped by vaccine responsiveness, and for subjects grouped by immunization schedule are illustrated in Figure 10.

The change in proliferative response to gp160 was significantly different between vaccine responders and non-responders (<0.001 , Wilcoxon, one tailed). The gp160 proliferation responses induced by Schedule B (6 doses) were
5 greater than those induced by Schedule A (3 doses) ($P<0.10$, Wilcoxon, one tailed).

Nineteen of the 21 subjects who developed proliferative responses to gp160 also developed a humoral response (vaccine responders). The maximum mean lymphocyte stimulation index (LSI) to gp160 observed for all vaccine responders was 50.1. However, each vaccine responder's response was variable (peak values ranging from a LSI of 3 to 171) (Fig. 7), as was the temporal relationship to vaccination of the magnitude and duration of the cellular responses to
15 gp160 (Figure 9).

H. Discussion of Results

Despite the limited sample size of this trial, several factors were demonstrated to be associated with
20 vaccine immunogenicity. Six of 15 (40 percent) of the subjects on Schedule A versus 13 of 15 (87 percent) of the subjects on Schedule B were vaccine responders ($P=0.02$ Fisher's, two-tailed) (Fig. 7). Of the 16 subjects with a mean baseline CD4 count greater than 600 per milliliter, 13
25 (81 percent) were vaccine responders, as opposed to 6 of 14 (43 percent) subjects whose mean entry CD4 count was less than 600 cells per milliliter ($P=0.07$ Fisher's, two-tailed). As summarized in Table 8, multiple immunizations improved immunogenicity, even among patients with baseline CD4 counts
30 less than 600 cells per milliliter. For example, 5 of 6 subjects on Schedule B (6 injections) were vaccine responders as compared to only 1 of 8 who received the 3 injection regimen (Schedule A) $P=0.03$ Fisher's, two-tailed) (Table 8).

TABLE 8

GP 160 Vaccine Immune Responsiveness by
Baseline CD4 Count and Immunization Schedule

	CD4 Count	N	# Responders (%)	# Non Responders (%)
5	SCHEDULE A			
10	>600	7	5 (71%)	2 (29%)
	500-600	5	1 (20%)	4 (80%)
	<500	3	0 (0%)	3 (100%)
15	Subtotal	15	6 (40%)	9 (60%)
	SCHEDULE B			
20	>600	9	8 (89%)	1 (11%)
	500-600	2	2 (100%)	0 (0%)
	<500	4	3 (75%)	1 (25%)
25	Subtotal	15	13 (87%)	2 (13%)
	TOTAL	30	19 (63%)	11 (37%)

The therapeutic use of vaccines was introduced by Pasteur in the 19th century for the treatment of acute rabies infection. But the utility of this approach in the treatment of other infections has not been extensively explored. Although there are other examples of post infection modification of viral-specific immunity (such as after hepatitis A or B exposure), there are no well documented studies in man which demonstrate the feasibility of this approach for an established or chronic viral infection.

Here, the invention provides virus-specific immune modification by active immunization after infection. Specifically, an HIV envelope gene derived gp160 vaccine augmented the human host directed viral-specific humoral and cellular responses in 19 of 30 early HIV infected persons.

This study qualitatively and quantitatively measured distinct antibody responses to specific HIV epitopes in natural infection versus post infection immunization. In this way, an accurate determination of vaccine induced humoral immunogenicity in already infected persons was documented in 70 percent of the subjects. For example, twenty subjects (19 vaccine responders and 1 vaccine non-responder) seroconverted to specific envelope epitopes.

Seroconversion associated only with vaccination (epitopes 241, 254, and 342) occurred in 10 subjects.

Additionally, variations in humoral responses to this vaccine, as characterized by epitope mapping, will
5 permit prospective cause and effect analysis of specific antibody responses, and allow unique opportunities to characterize potential immunoregulatory mechanisms not elicited during a natural infection.

Although the in vivo relevance of serum neutraliz-
10 ing activity is presently unknown, the observation of increased neutralizing activity against disparate HIV strains (IIIB, RF, MN) in 4 of 5 vaccine responders suggests that post-infection immunization induced changes in functional antibodies. The test vaccine induced increases in
15 serum neutralization capacity against distinct HIV strains and will potentially aid in the definition of group specific neutralization epitopes.

A proliferative response to HIV envelope proteins rarely occurs in natural HIV infection. However, after
20 immunization with gp160, specific T-cell proliferative responses were documented in 21 (70 percent) of the subjects. The reason for this difference is unclear. One possibility is that the new proliferative response may be directed against an envelope epitope(s) unique to the
25 vaccine (as a result of vaccine production methodology or alternative in vivo antigen processing). Alternatively, the protein used in the proliferation assay may not stimulate primary T-cell proliferative responses against homologous "wild type" envelopes of natural virus. However, additional
30 evidence that vaccination boosts the host cellular immune response has been obtained: selected vaccine responders demonstrated HIV-IIIB type-specific cytotoxic T-cell responses following booster immunization.

The factors responsible for vaccine
35 immunoresponsiveness in HIV infected persons remain to be clarified. Even in early HIV infection, individuals respond suboptimally to a variety of vaccines as compared to matched controls. This hyporesponsiveness has been related to early

B cell dysregulation and T-cell dysfunction. Here, vaccine immunoresponsiveness was associated with baseline CD4 cell count, which is consistent with the hypothesis that the immunological status of the host is an important determinant of vaccine responsiveness. However, the immunization schedule within specific T-cell count intervals also influenced vaccine responsiveness: Schedule B (6 injections) was superior. Indeed, the decreased vaccine response observed in the subjects with lower CD4 cell counts could be improved by an increased number of vaccinations which suggests that further modifications in dosage, regimen, adjuvants or formulation, could be anticipated to further improve host immunoresponsiveness.

Although concerns have been raised about the safety of active immunization of HIV infected persons with HIV specific vaccine products, there was no evidence of immune-specific toxicity. Quantitative cultures, DNA polymerase chain reaction assays and serum antigen assays show an increased in vivo HIV load. An excellent in vivo marker of HIV replication, the rate of CD4 cell decline, was favorably influenced among the subjects, especially those classified as vaccine responders. The change in mean CD4 counts for responders was -0.2 percent and was -7.3 percent for non-responders. The data demonstrates that post-infection immune responsiveness was not associated with an increase in CD4 destruction and suggests an association with decreased HIV replication in vivo.

The vaccination results in this study were also compared with a database of ten infected and untreated individuals matched for age, ethnic group, and baseline CD4 cell count. The mean CD4 count decreased by 8.7 percent in this reference group, decreased by 7.2 percent in the subjects assigned to Schedule A, and increased by 0.6 percent in subjects assigned to Schedule B. These results indicate that post-infection vaccination with recombinant HIV envelope protein is feasible, and furthermore the results are encouraging with respect to the prophylactic uses of such vaccines.

WHAT IS CLAIMED IS:

1 1. A method for treating an individual infected
2 with human immunodeficiency virus (HIV) comprising adminis-
3 tering a recombinant HIV envelope protein to the infected
4 individual.

1 2. A method according to claim 1, wherein the
2 recombinant protein is administered in a dose of about 1 to
3 100 micrograms per kilogram of body weight.

1 3. A method according to claim 1, wherein the
2 recombinant protein is administered in a dose of about 10 μ g
3 to about 4000 μ g.

1 4. A method according to claim 1, wherein the
2 recombinant protein is administered in a dose of about 40 μ g
3 to about 1280 μ g.

1 5. A method according to claim 3, wherein at
2 least three doses are administered.

1 6. A method according to claim 4, wherein at
2 least six doses are administered.

1 7. A method according to claim 5, wherein each
2 dose is administered at an interval of about 30 to 60 days.

1 8. A method according to claim 6, wherein each
2 dose is administered at an interval of about 30 to 60 days.

1 9. A method for treating an individual infected
2 with human immunodeficiency virus (HIV) comprising:
3 administering a recombinant HIV envelope protein
4 to the infected individual in an amount sufficient to elicit
5 an increase in HIV-specific cellular or humoral immune
6 responses.

1 10. A method according to claim 1, wherein the
2 recombinant protein is produced by a baculovirus insect cell
3 expression system.

1 11. A method according to claim 3, wherein the
2 recombinant protein is produced by a baculovirus insect cell
3 expression system.

1 12. A method according to claim 5, wherein the
2 recombinant protein is produced by a baculovirus insect cell
3 expression system.

1 13. A method according to claim 1, wherein the
2 recombinant protein has a molecular weight of approximately
3 145,000.

1 14. A method according to claim 3, wherein the
2 recombinant protein has a molecular weight of approximately
3 145,000.

1 15. A method according to claim 5, wherein the
2 recombinant protein has a molecular weight of approximately
3 145,000.

1 16. A method according to claim 1, wherein the
2 HIV envelope protein is at least one of gp160, gp120, and
3 gp41.

1 17. A method according to claim 3, wherein the
2 HIV envelope protein is at least one of gp160, gp120, and
3 gp41.

1 18. A method according to claim 5, wherein the
2 HIV envelope protein is at least one of gp160, gp120, and
3 gp41.

1 19. A method according to claim 1, wherein the
2 recombinant protein is expressed by the baculovirus insect
3 cell vector Ac3046.

1 20. A method according to claim 3, wherein the
2 recombinant protein is expressed by the baculovirus insect
3 cell vector Ac3046.

1 21. A method according to claim 5, wherein the
2 recombinant protein is expressed by the baculovirus insect
3 cell vector Ac3046.

1 22. A method according to claim 1, wherein the
2 recombinant protein is agglomerated into particles having a
3 molecular weight of at least about 2,000,000.

1 23. A method according to claim 3, wherein the
2 recombinant protein is agglomerated into particles having a
3 molecular weight of at least about 2,000,000.

1 24. A method according to claim 5, wherein the
2 recombinant protein is agglomerated into particles having a
3 molecular weight of at least about 2,000,000.

1 25. A method according to claim 1, wherein the
2 recombinant protein is combined with an adjuvant.

1 26. A method according to claim 3, wherein the
2 recombinant protein is combined with an adjuvant.

1 27. A method according to claim 5, wherein the
2 recombinant protein is combined with an adjuvant.

1 28. A method for treating an individual infected
2 with human immunodeficiency virus (HIV) comprising adminis-
3 tering to an infected individual a composition including a
4 recombinant HIV envelope protein and an alum adjuvant,
5 wherein the recombinant protein is formed into particles
6 having a molecular weight of at least about 2,000,000.

1 29. A method according to claim 28, wherein the
2 recombinant protein is produced by a baculovirus insect cell
3 expression system.

1 30. A method according to claim 28, wherein the
2 recombinant protein is selected from the group consisting of
3 recombinant gp160, recombinant gp120, recombinant gp41, a
4 recombinant HIV envelope protein having a molecular weight
5 of about 145,000, and a recombinant protein expressed by
6 vector Ac3046.

1 31. A method according to claim 28, wherein
2 the recombinant protein comprises about 757 successive amino
3 acids of gp160 and substantially excludes about 40 succes-
4 sive terminal amino acids of gp160.

1 32. A method according to claim 28, wherein the
2 recombinant protein is administered in a dose of about 10 μ g
3 to about 4000 μ g.

1 33. A therapeutic HIV vaccine composition
2 comprising a recombinant HIV envelope protein and an alum
3 adjuvant, wherein the recombinant protein is formed into
4 particles having a molecular weight of at least about
5 2,000,000.

1 34. A composition according to claim 33, wherein
2 the recombinant HIV envelope protein is provided in an
3 amount of about 10 μ g to 4000 μ g per dose.

1 35. A composition according to claim 34, wherein
2 the recombinant protein is produced by a baculovirus insect
3 cell expression system.

1 36. A composition according to claim 34, wherein
2 the recombinant protein includes about 757 successive amino
3 acids of gp160 and substantially excludes about 40 terminal
4 amino acids of gp160.

1 / 39

ISOLATION AND ENGINEERING OF HIV-1 env GENE

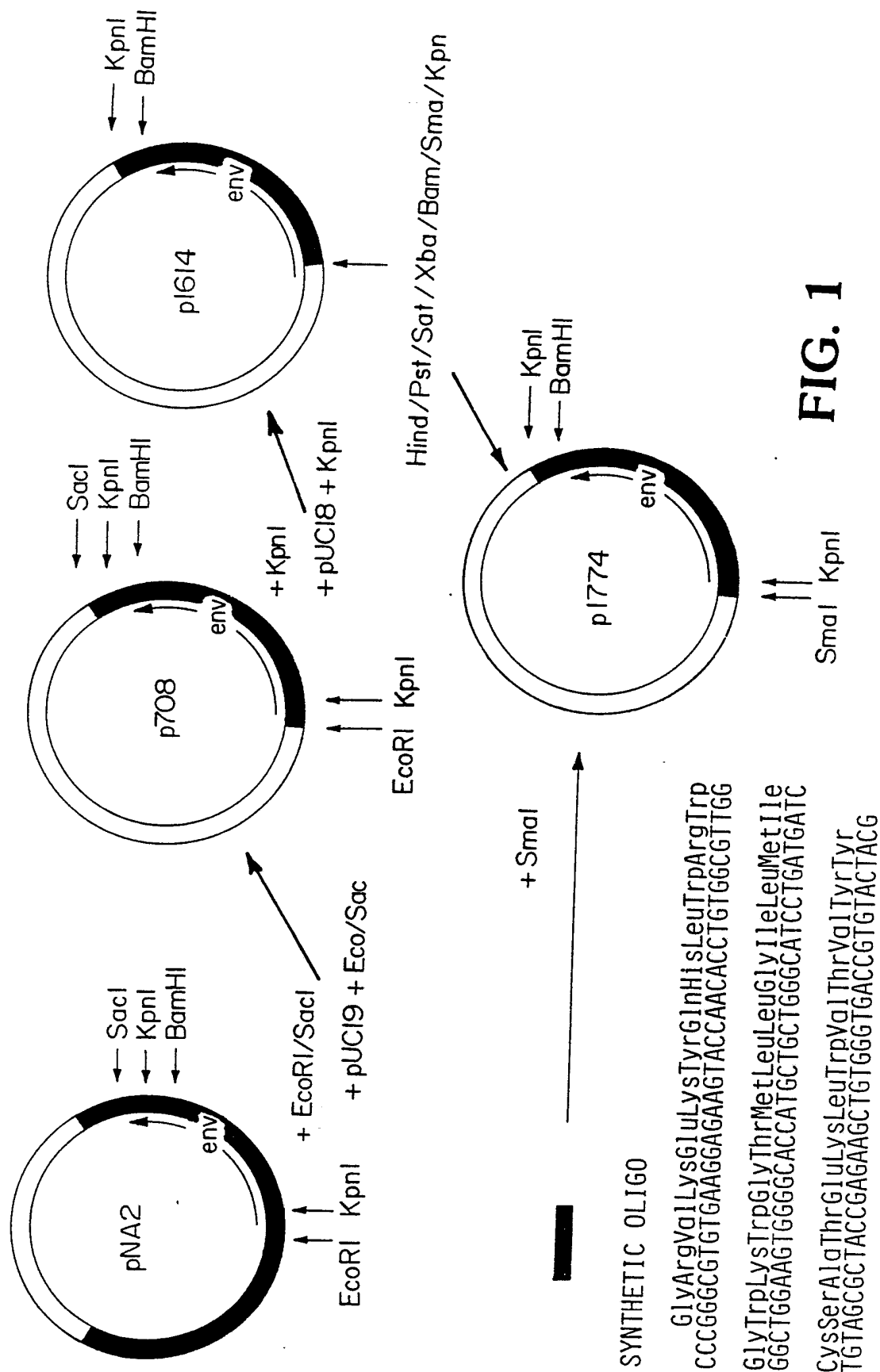


FIG. 1

SUBSTITUTE SHEET

2 / 39

CONSTRUCTION OF RECOMBINATION VECTOR p3046

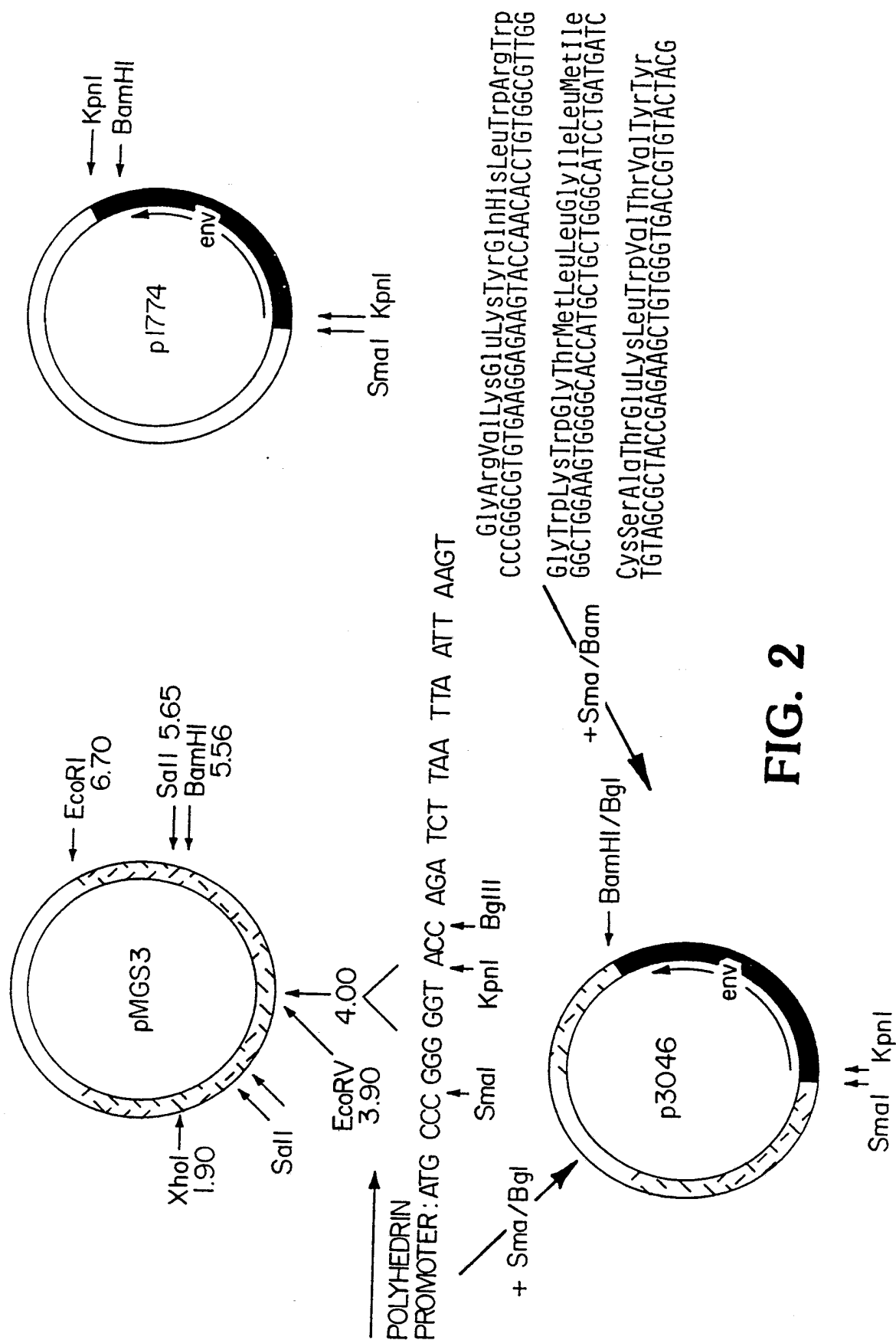


FIG. 2

3 / 39

NUCLEOTIDE SEQUENCE OF DNA FLANKING
THE Ac3046 gp160 CODING SEQUENCES

TGCTGATATC ATGGAGATAA TTAAAATGAT AACCATCTCG CAAATAAATA
-100

AGTATTTTAC TGTTTTCGTA ACAGTTTTGT AATAAAAAAA CCTATAAATA
-50

ATG -----/3046/----- TAATTAATTAA GT ACC GAC TCT GCT GAA GAG
+1 +2257

GAG GAA ATT CTC CTT GAA GTT TCC CTG GTG TTC AAA GTA AAG GAG
+2287

TTT GCA CCA GAC GCA CCT CTG TTC ACT GGT CCG GCG TAT TAA
+2332 +2374

FIG. 3

SUBSTITUTE SHEET

FIG. 4e

AAT	ACC	AAT	AGT	AGT	AGC	GGG	AGA	ATG	ATA	ATG	GAG	GAG
TTTA	TGG	TTA	TCA	TCA	TCG	CCC	TCT	TAC	TAT	TAC	CCT	CTC
Asn	Thr	Asn	Ser	Ser	Ser	Gly	Arg	Met	Ile	Met	Gly	Glu
			145						150			155

[illegible]

GTG	CAG	AAA	GAA	TAT	GCA	TTC	TTT	TAT	AAA	CTT	GAT	ATA	GTA	CCA
CAC	GTC	TTT	CTT	ATA	CGT	AAG	AAA	ATA	TTT	GAA	CTA	TAT	CAT	GGT
Val	Gln	Lys	Glu	Tyr	Ala	Phe	Phe	Tyr	Lys	Leu	Asp	Ile	Val	Pro
			175						180					185

ATA	GAT	AAT	ACC	AGC	TAT	AGG	TTG	ATA	AGT	TGT	AAC	ACC	D	GTC
TAT	CTA	TTA	TGG	TCG	ATA	TCC	AAC	TAT	TCA	ACA	TTG	TGG	d	CAG
Ile	Asp	Asn	Thr	Ser	Tyr	Arg	Leu	Ile	Ser	Cys	Asn	Thr	e	Val
				190					195				1	200

SUBSTITUTE SHEET

SUBSTITUTE SHEET

[illegible]

FIG. 4h

SUBSTITUTE SHEET

12 / 39

FIG. 4i

GGA CCT Gly	AAA TTT Lys	ATA TAT Ile	GGA CCT Gly	AAT TTA Asn	ATG TAC Met	AGA TCT Arg	CAA GTT Gln	GCA CGT Ala	CAT GTA His	325	330	M a e 3	TGT ACA Cys	AAC TTG Asn	ATT TAA Ile	AGT TCA Ser	AGA TCT Arg	335
GCA CGT Ala	AAA TTT Lys	TGG ACC Trp	AAT TTA Asn	GCC CGG Ala	ACT TGA Thr	TTA AAT Leu	AAA TTT Lys	CAG GTC Gln	ATA TAT Ile	340	345	AMN lah uee 111	GCT CGA Ala	AGC TCG Ser	AAA TTT Lys	TTA AAT Leu	AGA TCT Arg	350
GAA CTT Glu	CAA GTT Gln	TTT AAA Phe	GGA CCT Gly	AAT TTA Asn	AAT TTA Asn	AAA TTT Lys	ACA TGT Thr	ATA TAT Ile	ATC TAG Ile	355	360	M n l 1	TTT AAA Phe	AAG TTC Lys	CAA GTT Gln	TCC AGG Ser	TCA AGT Ser	365
												D d e 1	TTT AAA Phe	AAG TTC Lys	CAA GTT Gln	TCC AGG Ser	TCA AGT Ser	365

SUBSTITUTE SHEET

[illegible]

FIG. 41

16 / 39

FIG. 4m

AGT GAA TTA TAT AAA GTA GTA AAA ATT GAA CCA TTA GGA
 TCA CTT AAT ATA TTT TTT CAT CAT TTT TAA CTT GGT AAT CCT
 Ser Glu Leu Tyr Lys 485 Lys Val Val Lys 490 Ile Glu Pro Leu Gly
 495

M b o 2

SS
et
cy
11 |

GTA GCA CCC ACC AAG AAG AGA GTG CAG AGA GAA AAA
 CAT CGT GGG TGG TTC TTC TCT TCT CAC CAC TCT CTT TTT
 Val Ala Pro Thr Lys 500 Arg Arg Val Val Gln Arg Glu Lys
 510

F n u 4 H

S
S e c 1
t y 1 |

A l u 1

AGA GCA GTG GGA ATA GGA GGT GGA GCA
 TCT CGT CAC CCT CCT TAT TAT CGT CGT
 Arg Ala Val Gly Gly Ile Ile Ala Leu Phe Phe Phe
 515 520 525

SUBSTITUTE SHEET

[illegible]

FIG. 4n

[illegible]

FIG. 4p

[illegible]

FIG. 4r

SUBSTITUTE SHEET

23 / 39

Fig. 4t

NUMBER OF OPEN READING FRAME BASES: 2253

NUMBER OF AMINO ACID CODONS: = 2253 + 3 = 751

AMINO ACID	NUMBER	WEIGHT.	TOTALS
GLY -	53	75.1	3,980.3
GLU -	41	147.1	6,031.1
ASP -	25	133.1	3,327.5
VAL -	48	117.1	5,620.8
ALA -	37	89.1	3,296.7
ARG -	39	174.1	6,793.8
SER -	28	105.1	2,942.8
LYS -	42	146.2	6,140.4
ASN -	58	132.1	7,661.8
MET -	17	149.2	2,536.4
ILE -	57	131.2	7,478.4
THR -	53	119.1	6,312.3
TRP -	26	204.2	5,309.2
CYS -	21	121.2	2,545.2
TYR -	16	181.2	2,899.2
LEU -	61	131.2	8,003.2
PHE -	25	165.2	4,130.0
SER -	26	105.1	2,732.6
GLN -	38	146.2	5,555.6
HIS -	11	155.2	1,707.2
PRO -	29	115.1	3,337.9
TOTALS	751		98,342.4
			-H ₂ O (751 x 18)

Total estimated weight of
non-glycosylated polypeptide = 84,824.4

Total number of glycosylation sites:
28 x 2100 (wt per oligo saccharide)

Total estimated mol. wt. of gp160 = 84,824.4 + 58800
= 143,624.

SUBSTITUTE SHEET

Fig. 5a The sequence and corresponding codons on the top lines are those predicted from the engineering and by Wain-Hobson et al. (1985). The sequence along the bottom of each line is that which was determined for AC3046 from recombinant viral DNA.

[illegible]

25 / 39

Val	Thr	Glu	Asn	Phe	Asn	Met	Trp	Lys	Asn	Asp	Met	Val	Glu	Gln	6532
GTG	ACA	GAA	AAT	TTT	AAC	ATG	TGG	AAA	AAT	GAC	ATG	GTA	GAA	CAG	
90															
Met	Asp	Glu	Asp	Ile	Ile	Ser	Leu	Trp	Asp	Gln	Ser	Leu	Lys	Pro	6577
ATG	GAT	GAG	GAT	ATA	ATC	AGT	TTA	TGG	GAT	CAA	AGC	CTA	AAG	CCA	
	C														
	His														
Cys	Val	Lys	Leu	Thr	Pro	Leu	Cys	Val	Ser	Leu	Lys	Cys	Thr	Asp	6622
TGT	GTA	AAA	TTA	ACC	CCA	CTC	TGT	GTT	AGT	TTA	AAG	TGC	ACT	GAT	
Leu	TTG	Asn	Ala	Ser	Asn	Thr	Asn	Ser	Thr	Asn	Thr	Asn	Ser	Ser	6667
TTG	GGG	AAT	GCT	AGT	AAT	ACC	AAT	AGT	ACT	AAT	ACC	AAT	AGT	AGT	
	AA		A	(-----)										
	Lys		Asp												
Ser	Gly	Glu	Met	Met	Met	Glu	Lys	Gly	Glu	Ile	Lys	Asn	Cys	Ser	6712
AGC	GGG	GAA	ATG	ATG	ATG	GAG	AAA	GGA	GAG	ATA	AAA	AAC	TGC	TCT	
		AG		A											
		Arg		Ile											
150															
Phe	Asn	Ile	Ser	Thr	Ser	Ile	Arg	Gly	Lys	Val	Gln	Lys	Glu	Tyr	6757
TTC	AAT	ATC	AGC	ACA	AGC	ATA	AGA	GGT	AAG	GTG	CAG	AAA	GAA	TAT	
								A							
								Asp							

Fig. 5b

SUBSTITUTE SHEET

26 / 39

Fig. 5c

Ala GCA 	Phe TTT 	Phe TAT 	Lys AAA 	Leu CTT 	Asp GAT 	Ile ATA 	Ile ATA G Val	Pro CCA 	Ile ATA 	Val GAT 	Asn AAT 	Asp GAT ACT (------)	Thr ACT 	6802
Thr ACC 	Ser AGC 	Tyr TAT 	Thr ACG 	Thr ACA 	Ser AGT 	Cys TGT 	Asn AAC 	Thr ACC 	Ser TCA 	Val GTC 	Ile ATT 	Thr ACA 	Gln CAG 	6847
Ala GCC 	Cys TGT 	Pro CCA 	Lys AAG 	Val GTA 	Phe TTT 	Glu GAG 	Pro CCA 	Ile ATT 	Pro CCC 	Ile ATA 	His CAT 	Tyr TAT 	Cys TGT 	6892
Ala GCC 	Pro CCG 	Ala GCT 	Gly GGT 	Phe TTT 	Ile ATT 	Leu CTA 	Lys AAA 	Cys TGT 	Asn AAT 	Asn AAT 	Lys AAG 	Thr ACG 	Phe TTC 	6937
Asn AAT 	Gly GGA 	Thr ACA 	Gly GGA 	Pro CCA 	Thr ACA 	Asn AAT 	Val GTC 	Ser AGC 	Thr ACA 	Val GTA 	Gln CAA 	Cys TGT 	Thr ACA 	6982
His CAT 	Gly GGA 	Ile ATT 	Arg AGG 	Pro CCA 	Val GTA 	Ser TCA 	Thr ACT 	Gln CAA 	Leu CTG 	Leu CTG 	Leu TTG 	Asn AAT 	Gly GGC 	7027

SUBSTITUTE SHEET

27 / 39

270	Ser	Leu	Ala	Glu	Glu	Glu	Val	Val	Ile	Arg	Ser	Ala	Asn	Phe	Thr	7072
	AGT	CTA	GCA	GAA	GAA	GAG	GTA	GTA	ATT	AGA	TCT	GCC	AAT	TTC	ACA	
						T										
						Asp										
290	Asp	Asn	Ala	Lys	Thr	Ile	Val	Gln	Leu	Asn	Asn	Gln	Ser	Val	Glu	7117
	GAC	AAT	GCT	AAA	ACC	ATA	GTA	CAG	CTG	AAC	AAC	CAA	TCT	GTA	GAA	
												AC				
												Thr				
310	Ile	Asn	Cys	Thr	Arg	Pro	Asn	Asn	Thr	Arg	Arg	Lys	Ser	Ile	Arg	7162
	ATT	AAT	TGT	ACA	AGA	CCC	AAC	AAC	ACA	AGA	AGA	AAA	AGT	ATC	CGT	
330	Ile	Gln	Arg	Gly	Pro	Gly	Arg	Ala	Phe	Val	Thr	Ile	Gly	Lys	Ile	7207
	ATC	CAG	AGG	GGA	CCA	GGG	AGA	GCA	TTT	GTT	ACA	ATA	GGA	AAA	ATA	
350	Gly	Asn	Met	Arg	Gln	Ala	His	Cys	Asn	Ile	Ser	Arg	Ala	Lys	Trp	7252
	GGA	AAT	ATG	AGA	CAA	GCA	CAT	TGT	AAC	ATT	AGT	AGA	GCA	AAA	TGG	
370	Asn	Ala	Thr	Leu	Lys	Gln	Ile	Ala	Ser	Lys	Leu	Arg	Glu	Gln	Phe	7297
	AAT	GCC	ACT	TTA	AAA	CAG	ATA	GCT	AGC	AAA	TTA	AGA	GAA	CAA	TTT	
7342	Gly	Asn	Asn	Lys	Thr	Ile	Ile	Phe	Lys	Gln	Ser	Ser	Gly	Gly	Asp	
	GGA	AAT	AAT	AAA	ACA	ATA	ATC	TTT	AAG	CAA	TCC	TCA	GGA	GGG	GAC	

Fig. 5d

SUBSTITUTE SHEET

Fig. 5e

Pro CCA 	Glu GAA 	Ile ATT 	Val GTA 	Thr ACG 	His CAC 	Ser AGT 	Phe TTT 	Asn AAT 	Cys TGT 	Gly GGA 	Gly GGG 	Glu GAA 	Phe TTT 	Phe TTC 	7387
Tyr TAC 	390 Cys TGT 	Asn AAT 	Ser TCA 	Thr ACA 	Gln CAA 	Leu CTG 	Phe TTT 	Asn AAT 	Ser AGT 	Thr ACT 	Trp TGG 	Phe TTT 	Asn AAT 	Ser AGT 	7432
Thr ACT 	Trp TGG 	Ser AGT 	Thr ACT 	Glu GAA 	Gly GGG 	Ser TCA 	Asn AAT 	Asn AAC 	Thr ACT 	Glu GAA 	Gly GGA 	Ser AGT 	Asp GAC 	Thr ACA 	7477
Ile ATC 	Thr ACA 	Leu CTC 	Pro CCA 	Cys TGC 	Arg AGA 	Ile ATA 	Lys AAA 	Gln CAA 	Phe TTT 	Ile ATA 	Asn AAC 	Met ATG 	Trp TGG 	Gln CAG 	7522
Glu GAA 	Val GTA 	Gly GGA 	Lys AAA 	Ala GCA 	Met ATG 	Tyr TAT 	Ala GCC 	Pro CCT 	Pro CCC 	Ile ATC 	Ser AGC 	Gly GGA 	Gln CAA 	Ile ATT 	7567
Arg AGA 	450 Cys TGT 	Ser TCA 	Ser TCA 	Asn AAT 	Ile ATT 	Thr ACA 	Gly GGG 	Leu CTG 	Leu CTA 	Leu TTA 	Thr ACA 	Arg AGA 	Asp GAT 	Gly GGT 	7612
Gly GGT 	Asn AAT 	Asn AAC 	Asn AAC 	Asn AAT 	Gly GGG 	Ser TCC 	Glu GAG 	Ile ATC 	Phe TTC 	Arg AGA 	Pro CCT 	Gly GGA 	Gly GGA 	Gly GGA 	7657

29 / 39

Asp GAT 	Met ATG 	Arg AGG 	Asp GAC 	Asn AAT 	Trp TGG 	Arg AGA 	Ser AGT 	Glu GAA 	Leu TTA 	Tyr TAT 	Lys AAA 	Val GTA 	7702
Val GTA 	Lys AAA 	Ile ATT 	Glu GAA 	Pro CCA 	Leu TTA 	Gly GGA 	Val GTA 	Ala GCA 	Pro CCC 	Thr ACC 	Lys AAG 	Arg AGA 	7747
Arg AGA 	Val GTG 	Val GTG 	Gln CAG 	Arg AGA 	Glu GAA 	Lys AAA 	Arg AGA 	Ala GCA 	Val GTG 	Gly GGA 	Ile ATA 	Ala GCT 	7792
gion Phe TTC 	Leu CTT 	Gly GGG 	Phe TTC 	Leu TTG 	Gly GGA 	Ala GCA 	Ala GCA 	Gly GGA 	Ser AGC 	Thr ACT 	Met ATG 	Arg CGG 	7837
Ser TCA 	Met ATG 	Thr ACG 	Leu CTG 	Thr ACG 	Val GTA 	Gln CAG 	Ala GCC 	Arg AGA 	Gln CAA 	Leu TTA 	Leu TTG 	Ile ATA 	7882
Val GTG 	Gln CAG 	Gln CAG 	Gln CAG 	Asn AAC 	Asn AAT 	Leu TTG 	Leu CTG 	Arg AGG 	Ala GCT 	Ile ATT 	Glu GAG 	Gln CAA 	7927
His CAT 	Leu CTG 	Leu TTG 	Gln CAA 	Leu CTC 	Thr ACA 	Val GTC 	Trp TGG 	Gly GGC 	Ile ATC 	Lys AAG 	Gln CAG 	Ala GCA 	7972

Fig. 5f

30 / 39

Fig. 5g

Arg AGA 	Ile ATC 	Leu CTG 	Ala GCT 	Val GTG 	Glu GAA 	Arg AGA 	Tyr TAC 	Leu CTA 	Lys AAG 	Asp GAT 	Gln CAA 	Gln CAG 	Leu CTC 	Leu CTG 	8017
Gly GGG 	Ile ATT 	Trp TGG 	Gly GGT 	Cys TGC 	Ser TCT 	Gly GGA 	Lys AAA 	Leu CTC 	Ile ATT 	Cys TGC 	Thr ACC 	Thr ACT 	Ala GCT 	Val GTG 	8062
Pro CCT 	Trp TGG 	Asn AAT 	Ala GCT 	Ser AGT 	Trp TGG 	Ser AGT 	Asn AAT 	Lys AAA 	Ser TCT 	Leu CTG 	Glu GAA 	Gln CAG 	Ile ATT 	Trp TGG 	8107
Asn AAT 	Asn AAC 	Met ATG 	Thr ACC 	Trp TGG 	Met ATG 	Glu GAG 	Trp TGG 	Asp GAC 	Arg AGA 	Glu GAA 	Ile ATT 	Asn AAC 	Asn AAT 	Tyr TAC 	8152
Thr ACA 	Ser AGC 	Leu TTA 	Ile ATA 	His CAT 	Ser TCC 	Leu TTA 	Ile ATT 	Glu GAA 	Glu GAA 	Ser TCG 	Gln CAA 	Asn AAC 	Gln CAG 	Gln CAA 	8197
Glu GAA 	Lys AAG 	Asn AAT 	Glu GAA 	Gln CAA 	Glu GAA 	Leu TTA 	Leu TTG 	Glu GAA 	Leu TTA 	Asp GAT 	Lys AAA 	Trp TGG 	Ala GCA 	Ser AGT 	8242
Leu TTG 	Trp TGG 	Asn AAT 	Trp TGG 	Phe TTT 	Asn AAC 	Ile ATA 	Thr ACA 	Asn AAT 	Trp TGG 	Leu CTG 	Trp TGG 	Tyr TAT 	Ile ATA 	Lys AAA 	8287

SUBSTITUTE SHEET

[illegible]

Fig. 5h

32 / 39

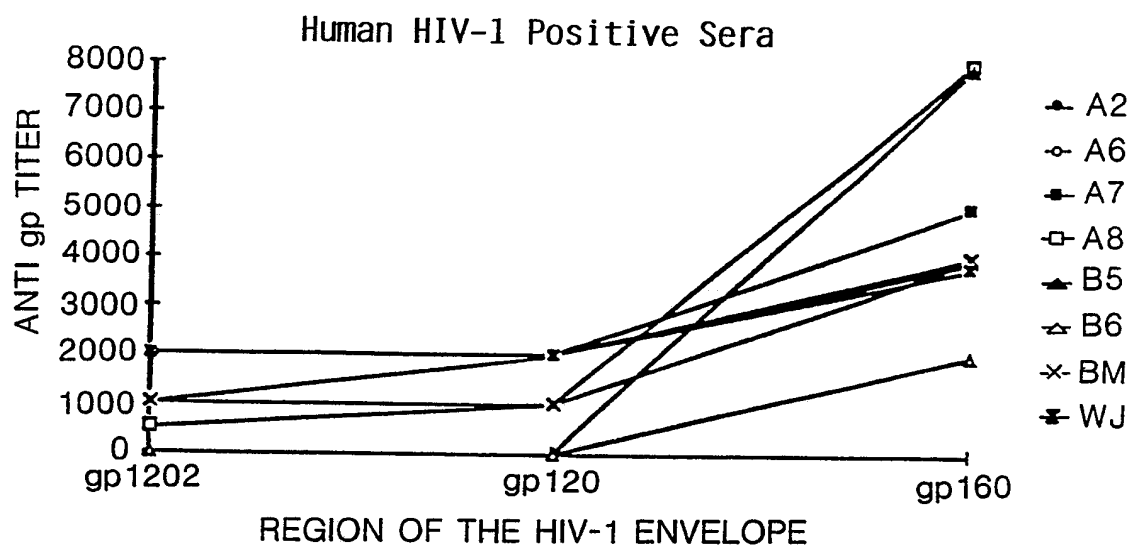
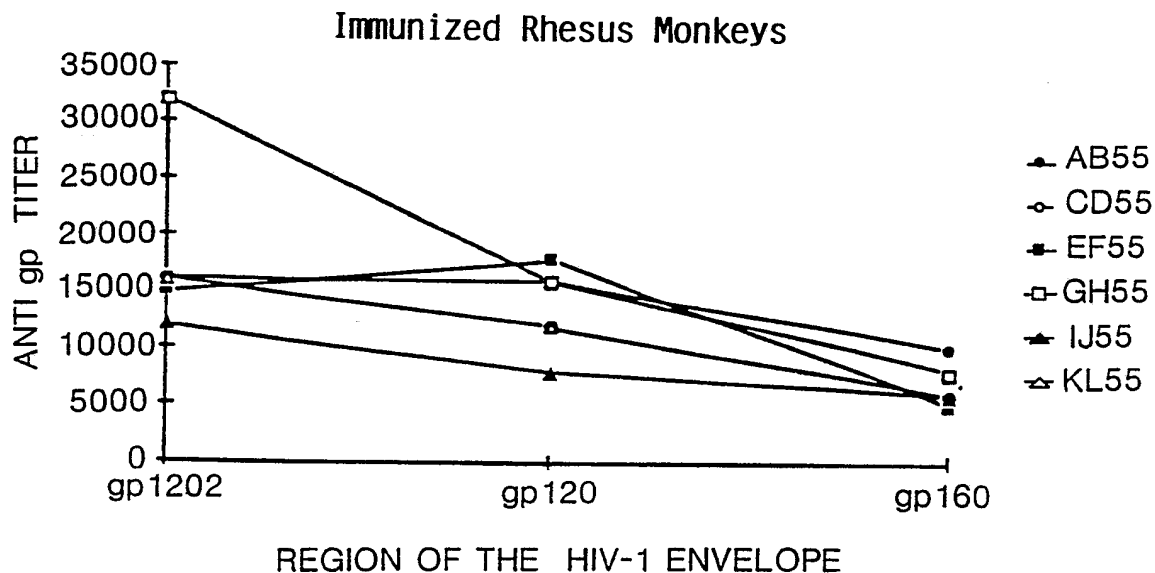
FIG. 6**FIG. 6a****SUBSTITUTE SHEET**

FIG. 7a

Summary gp 160 Vaccine Induced Immune Responses

	Patient	Group	Humoral Antibody Response to Specific Epitopes										Cellular Response				
			T-cell Proliferation														
RESPONDERS	Schedule A	8 15 17 10 20 22	49	88	106	241	254	300	308	342	422	448	582	735	Total gp 160 (peak I.S.I)		
			+	+	+	-	-	+	+	+	+	+	+	+	+	(25)	
			+	+	+	-	+	+	+	+	-	-	+	+	=	(71)	
			+	-	+	-	-	+	+	-	-	-	+	+	+	(23)	
			+	hb	+	+	-	-	-	-	-	-	-	+	-	(50)	
			+	-	+	-	-	-	-	-	-	-	-	+	-	(19)	
			+	-	+	-	-	-	-	-	-	-	+	+	-	(16)	
			2	2	2	2	4	4	4	4	4	4	4	4	4	4	(102)
			3	16	19	6	7	13	28	32	11	23	29	33	33	39	(171)
			Schedule B	1 3 16 19 6 7 13 28 32 11 23 29 33	2 2 2 2 4 4 4 4 6 6 6 6	+	+	+	-	-	+	+	+	+	+	+	+
+	+	+				-	-	+	+	+	+	+	+	+	+	(20)	
+	+	+				-	-	+	+	+	+	+	+	+	+	(34)	
+	+	+				-	-	+	+	+	+	+	+	+	+	(95)	
+	+	+				-	-	+	+	+	+	+	+	+	+	(27)	
+	+	+				-	-	+	+	+	+	+	+	+	+	(3)	
+	+	+				-	-	+	+	+	+	+	+	+	+	(35)	
+	+	+				-	-	+	+	+	+	+	+	+	+	(24)	
+	+	+				-	-	+	+	+	+	+	+	+	+	(8)	
+	+	+				-	-	+	+	+	+	+	+	+	+	(158)	
+	+	+	-	-	+	+	+	+	+	+	+	+	(28)				

33 / 39

FIG. 7b

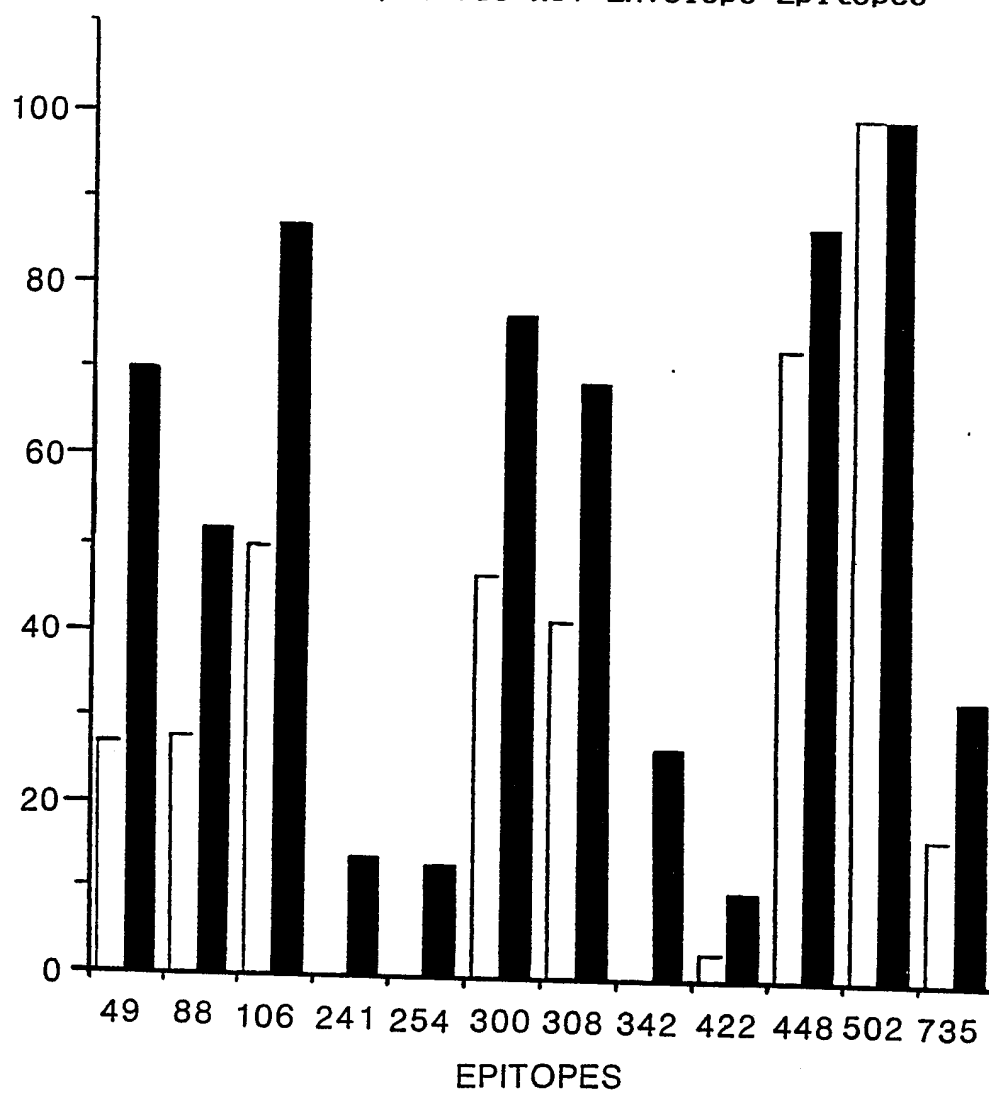
Patient	Group	Humoral Antibody Response to Specific Epitopes										Cellular Response				
		49	88	106	241	254	300	308	342	422	448	582	735	Total gp 160 (peak I.SI)		
NON-RESPONDERS																
2	1	-	-	+	-	-	+	+	-	+	+	-	.	34 / 39		
18	1	-	+	-	-	-	-	-	-	-	+	-	.			
5	3	+	-	-	-	-	+	+	-	+	+	+	.			
12	3	+	+	+	-	-	-	-	-	+	+	+	.			
14	3	+	-	+	-	-	+	+	-	+	+	-	.			
21	3	-	-	+	hb	-	+	hb	-	+	+	-	.	(10)		
35	3	-	-	+	-	-	-	-	+	+	+	-	.			
27	5	-	-	+	-	-	+	nd	-	-	+	-	.			
31	5	+	-	-	-	-	+	+	-	+	+	-	.			
Schedule A																
4	2	-	-	+	-	-	+	+	-	+	+	-	.		(28)	
24	6	-	-	+	-	-	+	+	-	-	+	-	.			
Schedule B																

SUBSTITUTE SHEET

35 / 39

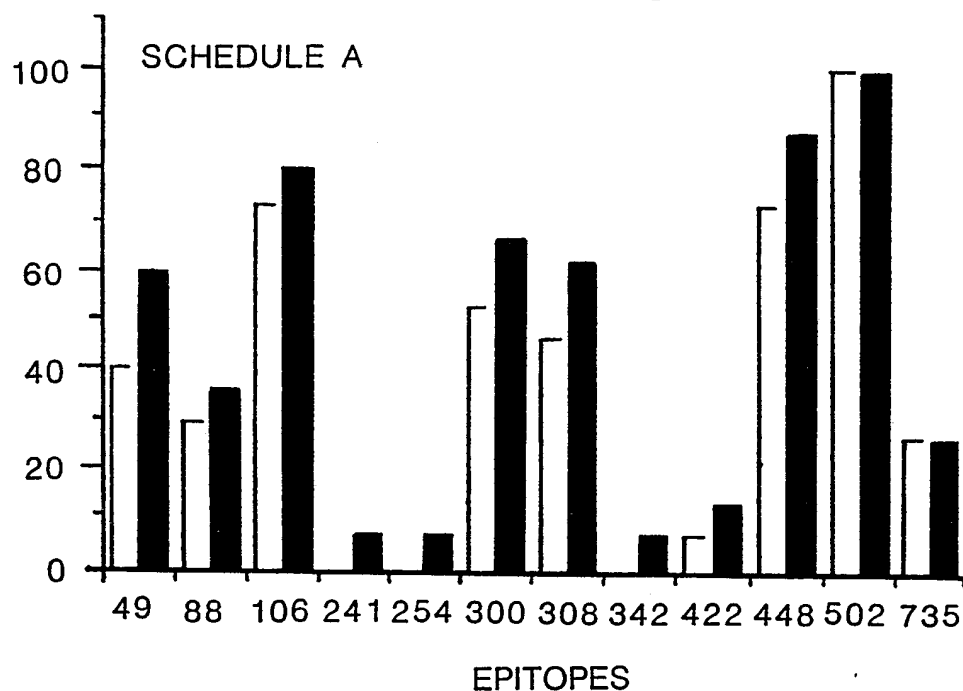
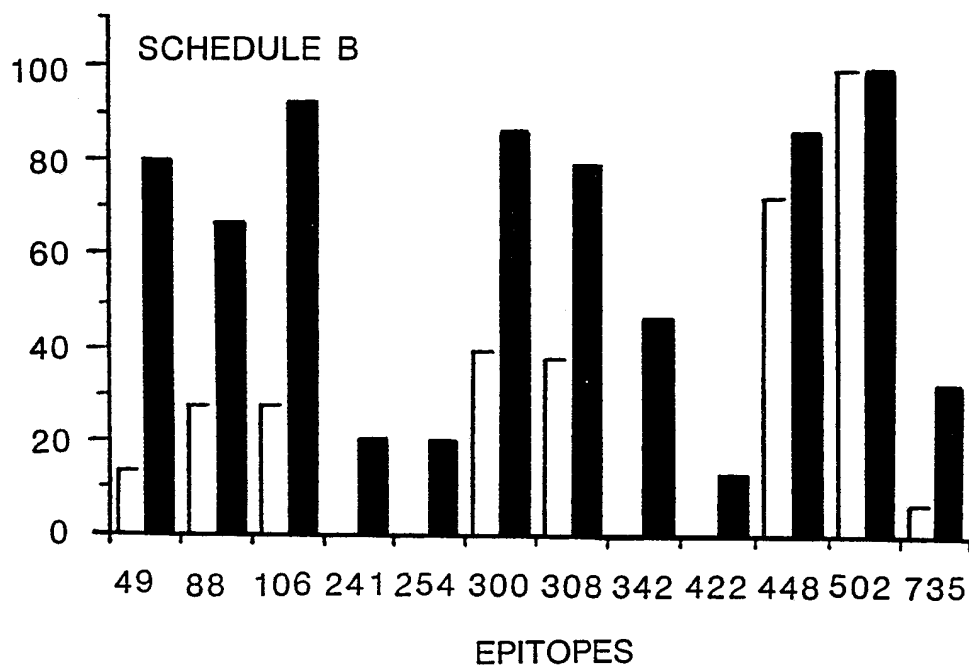
FIG. 8a

Vaccine Induced Antibody Directed
Against Specific HIV Envelope Epitopes



SUBSTITUTE SHEET

36 / 39

FIG. 8b**FIG. 8c****SUBSTITUTE SHEET**

Vaccine-Induced T Cell Proliferation to gp160

FIG. 9a

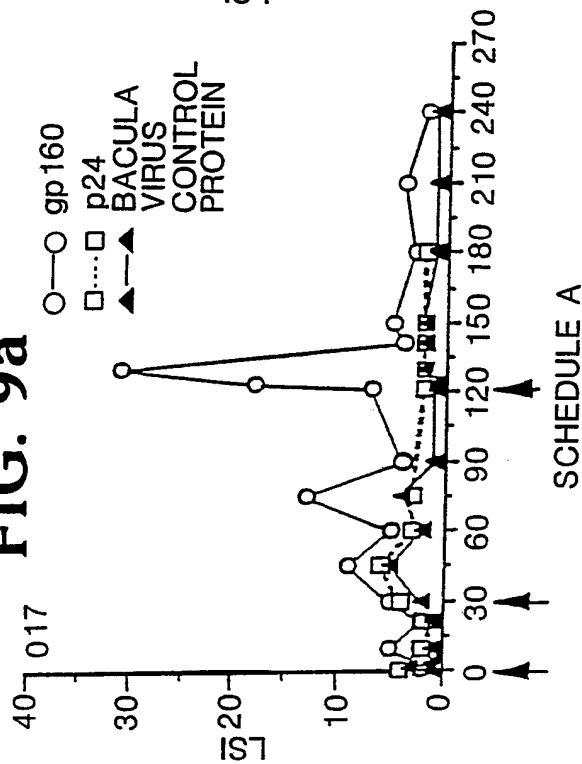


FIG. 9b

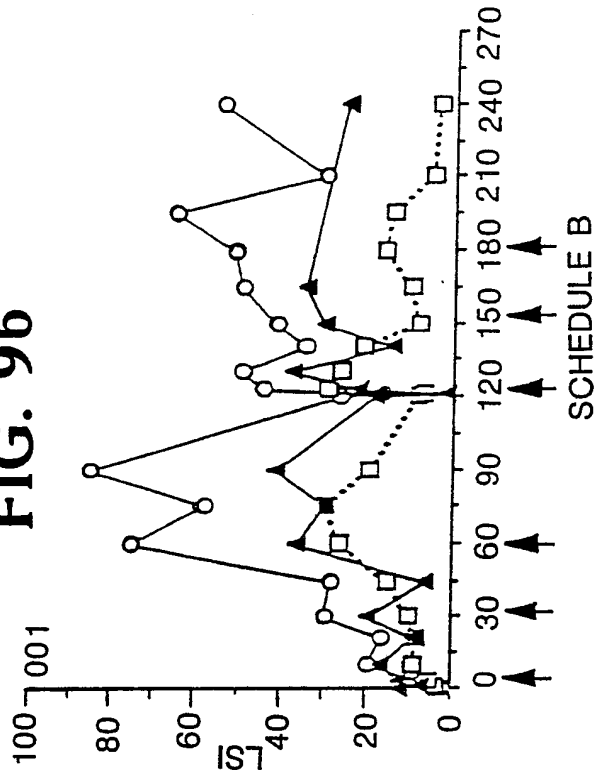


FIG. 9c

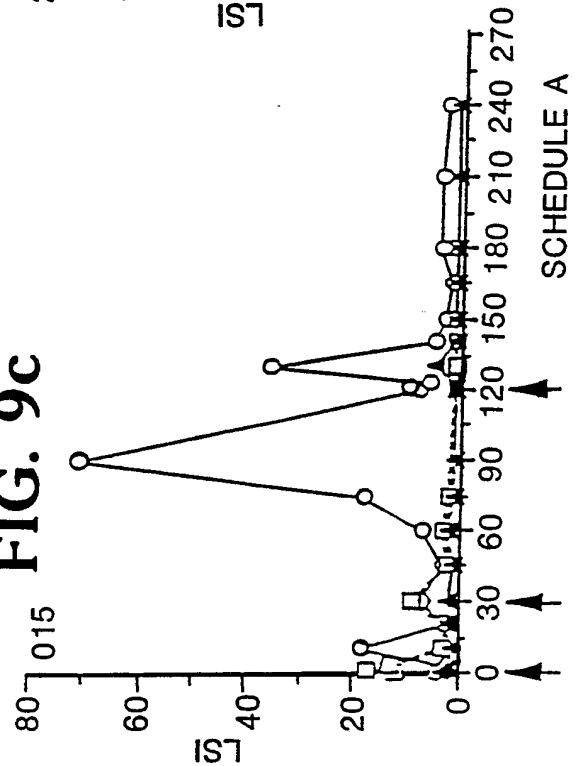
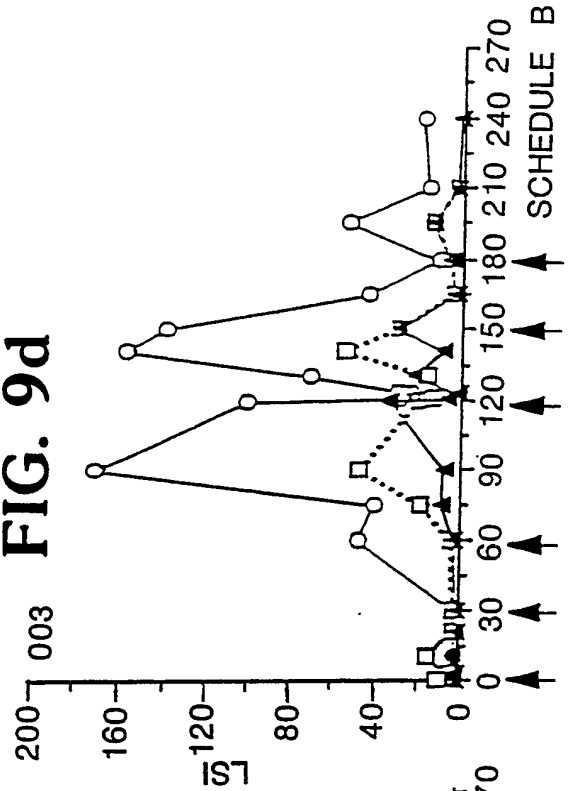


FIG. 9d



SUBSTITUTE SHEET

Lymphocyte Proliferation Response Associated with Vaccination

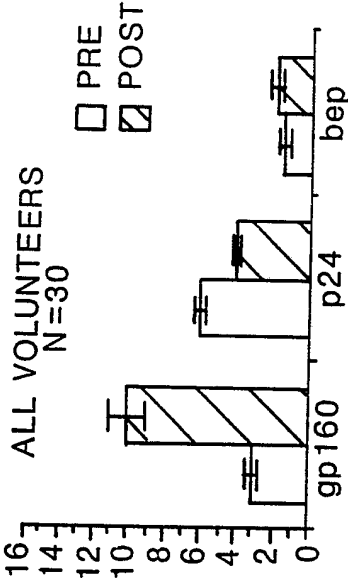


FIG. 10a

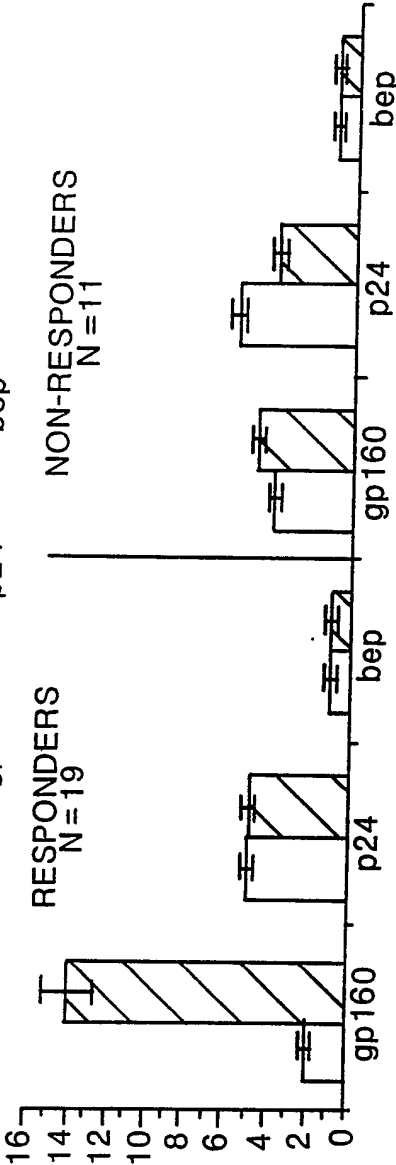


FIG. 10b

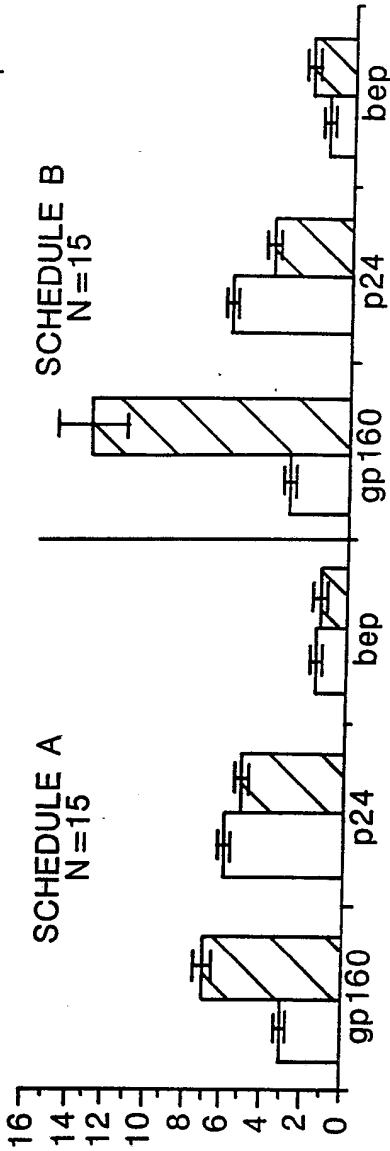
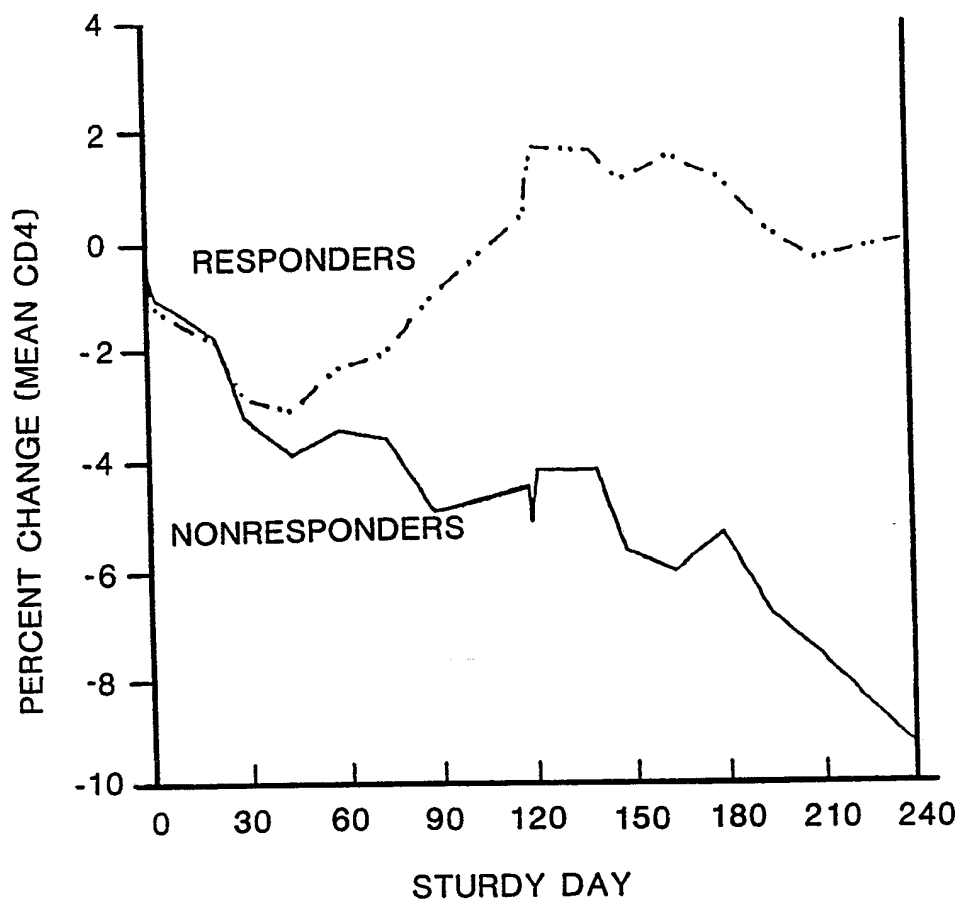


FIG. 10c

39 / 39

FIG. 11

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 92/04980

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl. 5 C12N15/49; C12N15/86; A61K39/21; C07K13/00		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
Int.Cl. 5	C07K ; C12N	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
X	EP,A,0 327 180 (MICROGENESYS INC.) 9 August 1989 see the whole document -----	1-36
<p>¹⁰ Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search		Date of Mailing of this International Search Report
30 SEPTEMBER 1992		19. 10. 92
International Searching Authority		Signature of Authorized Officer
EUROPEAN PATENT OFFICE		CHAMBONNET F.J.

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
Remark: Although claims 1 to 32 are directed to a method of treatment of the human body the search has been carried out and based on the alleged effects of the compound/composition.
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

9204980
61379

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 30/09/92

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-0327180	09-08-89	AU-A- 2955789 JP-A- 2203793	03-08-89 13-08-90
